ПЛАЗМОХИМИЧЕСКОЕ НАНЕСЕНИЕ СЛОЕВ SIC ДЛЯ УПРОЧНЕНИЯ ИНСТРУМЕНТАЛЬНЫХ СТАЛЕЙ

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Аннотация:

Рассмотрена технология плазменного нанесения упрочняющих слоев SiC и исследовано влияние плазмохимического нанесения данного покрытия на структурно-напряженное состояние поверхностного слоя инструментального материала.

Плазмохимия, карбид кремния, структурно-напряженное состояние, инструментальные стали, износостойкие покрытия

Проблема повышения стойкости металлообрабатывающего инструмента существует, пожалуй, с момента появления самого инструмента, оставаясь, тем не менее, и по сей день весьма актуальной.

Одним из достаточно распространенных способов повышения стойкости режущего инструмента является нанесение износостойких покрытий на его рабочую поверхность. К настоящему времени среди множества материалов широкое применение находят покрытия на основе карбидов и нитридов титана, вольфрама и др., получаемых методами химического или физического осаждения из газовой фазы.

Анализ литературных данных и практического опыта показывает, что ни один из известных методов получения покрытий не удовлетворяет всем требованиям, предъявляемым производством.

Выбор направления упрочняющей обработки определяется условиями работы, материалом и формой инструмента, технико-экономическими показателями, а также достижениями в освоении новых методов создания поверхностных слоев с улучшенными эксплутационными свойствами.

Успехи, достигнутые в применении высокочастотных индукционных генераторов низкотемпературной плазмы, создали предпосылки для использования плазменных потоков в различных технологических процессах, в том числе и плазмохимическом осаждении кремнийсодержащих покрытий [1].

В числе соединений кремния, получаемых методом плазмохимического осаждения (ПХО), карбид кремния занимает особое место. Благодаря высокой твердости (~ 15000-34000 МПа), теплостойкости и пониженной склонности к окислению, он может рассматриваться как перспективный материал для износостойких покрытий.

В настоящей статье авторы приводят многолетний опыт разработки и применения технологии нанесения упрочняющих карбидокремниевых покрытий на инструментальные стали и экспериментальные результаты последствий воздействия плазменной обработки на их физико-механические свойства.

Процесс напыления проводился на установке с генератором ВЧИ 11-63/1,76 мощностью 90 кВт с кварцевой разрядной камерой диаметром 120 мм, охватываемой индуктором диаметром 180 мм (рис.1). Процесс происходил при атмосферном давлении. В камере инициировался безэлектродный индукционный разряд инертного газа - аргона. Источником кремния служил кварцевый вкладыш, который погружением в плазменный разряд доводился до температуры эффективного испарения (абляции).

Пары двуокиси кремния поступали в плазму, где происходило разложение их на исходные компоненты и частичная ионизация. Поставщиком углерода служили пары этилового спирта или другого углеводородного соединения, которые после синтеза в парах SiO_2 переносились потоком плазмообразующего газа к обрабатываемому изделию. Напыляемый образец размещался в факеле ВЧИ-разряда в зоне, соответствующей получению стекловидного покрытия. Время напыления беспористого покрытия составляло 10-45 с.

В конструкции установки предусмотрена возможность регулирования расхода и направления

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потоков плазмообразующего газа, количества и состава химически-активных компонентов, подводимой к разряду мощности, что позволяет оказывать существенное влияние на характер плазменных процессов, контролировать процесс напыления и получать пленки заданного состава. Полученные на рабочих кромках инструмента пленки имели толщину порядка 0,5 - 0,8 мкм и стекловидную поверхность.

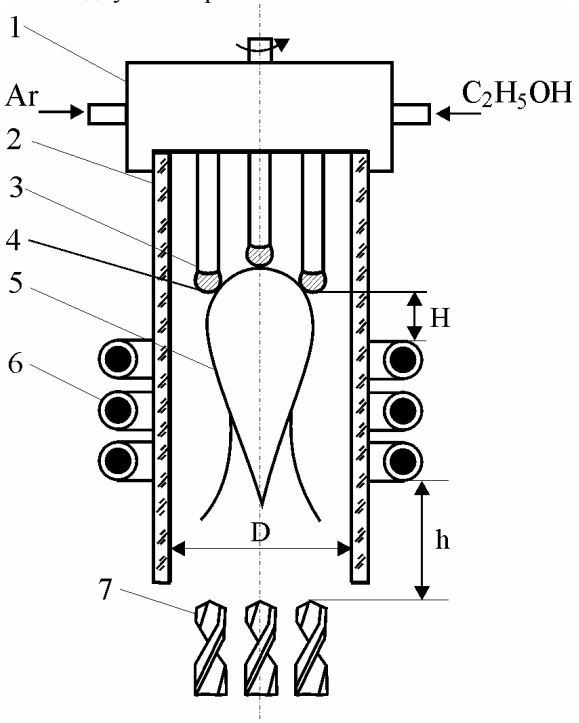

Рис.1. Схематическое устройство реакционно-разрядной камеры ВЧИ плазмотрона:
1 - система напуска плазмообразующего газа; 2 - разрядная камера; 3 - испаряемые элементы; 4 – аблирующая поверхность; 5 - плазменный сгусток; 6 – ВЧ индуктор; 7 - напыляемый образец

Состав пленок определялся методом ИК спектроскопии на спектрофотометре UR – 20 в области 2000-400 $см^{-1}$. Спектры пленок № 1 (рис.2) имеют характерный для SiC вид. Интенсивная полоса поглощения с максимумом при 825 $см^{-1}$ имеет сложную структуру, характеризующуюся наличием ряда перегибов и соответствует валентному колебанию связи Si-C. Слабая полоса ~ 1060 $см^{-1}$ свидетельствует о наличии в пленке оксидных включений.

Для определения точных значений перегибов полосы ν = 825 $см^{-1}$ применяли графический метод разделения сложного контура с использованием функции Лоренца. В результате были получены три полосы с максимумами 750, 820, 940 $см^{-1}$. Наибольшая интенсивность наблюдалась у полосы валентных колебаний Si-C-групп (ν = 820 $см^{-1}$). Формируемое покрытие представляет собой оксикарбонитрид кремния $Si_xO_{x-1}C_yN_z$. Содержание карбида превышает 50 масс.% [2].

Анализ состава методом ультрамягкой рентгеновской эмиссионной спектроскопии показал, что плотность валентных электронных состояний поверхностных слоев ~ 10 нм имеет структуру оксикарбидов. В более глубоких слоях до 60 нм пленка имеет плотность состояний характерную для α-SiC. Ближе к границе раздела вклад связей Si-O в плотности валентных состояний вновь резко возрастает. Методом Оже-спектроскопии в сочетании с ионным травлением построен эмиссионный профиль пленок. Показано, что концентрация азота также заметно повышается к границе раздела. Анализ химического сдвига L,VV-линий подтверждает, что поверхностный слой близок по составу к оксикарбиду, а объем к SiC.

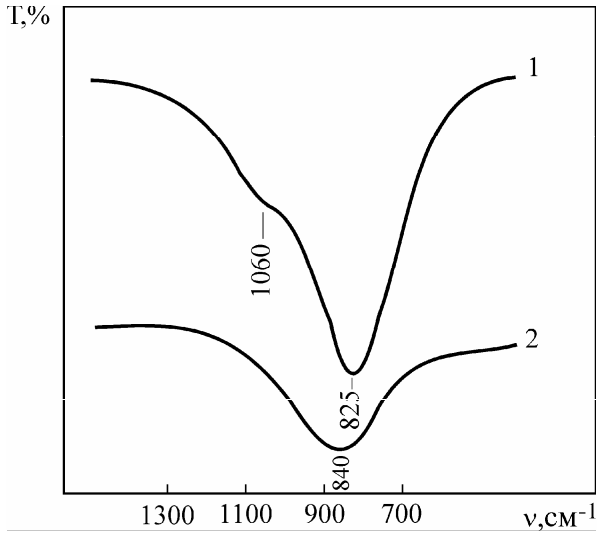

Рис.2. ИК спектр поглощения пленок карбида кремния (пленка №1) и нитрида кремния (пленка №2)

Опыт эксплуатации установки показал, что изменением параметров плазменного потока можно регулировать толщину и состав переходных слоев оксикарбонитридов. Это позволяет значительно улучшать адгезию покрытия.

При формировании стеклоподобной пленки с хорошей адгезией к поверхности добавочным упрочняющим фактором, кроме высокой твердости собственно пленки, являются термические напряжения, возникающие после ПХО при охлаждении в связи с разницей в коэффициентах линейного расширения и модулях упругости пленки и подложки.

На практике инструментальные стали используются в метастабильном состоянии, после закалки с низким или средним отпуском. В таких подложках ПХО вызывает протекание фазовых и структурных изменений, неоднозначно влияющих на прочностные свойства. В случае метастабильной подложки принципиально возможны следующие эффекты от воздействия высокоэнергетической плазменной струи: повторная закалка микрообъемов, разогретых выше температур фазовых превращений;

доотпуск микрообъемов, разогретых до температур ниже A_1, но выше температур предшествовавшего объемного отпуска. При этом приповерхностные участки разогреваются непосредственно плазменным потоком, а глубже расположенные слои - за счет теплопроводности. В микрообъемах происходят сложные превращения, характерные для закалки и отпуска сталей перлитного и карбидного классов изучаемых марок, отличающиеся от процессов при объемной термической обработке кинетикой и полнотой протекания. Этот вывод подтверждается результатами определения микротвердости и рентгеноструктурного анализа. В нетеплостойкой стали 40Х уменьшение полуширины b/2 рефлекса $(220)_\alpha$ свидетельствует о снижении уровня микроискажений и укрупнении блочной структуры α-железа, т.е. о преобладании эффектов отпуска над закалочными. Эти процессы интенсивнее идут в случае исходной мартенситной структуры, по сравнению со структурой троостита. Еще более чувствительным параметром является фактор ослабления интенсивности B, величина которого, характеризующая статические и динамические искажения решетки, меняется в значительных пределах – от нескольких процентов до 450%. Таким образом, действие ПХО проявляется как на уровне напряжений, действующих в объеме зерна и между зернами, так и в еще большей степени - на величину и знак напряжений, возникающих внутри объемов с размерами порядка нескольких элементарных кристаллических ячеек [3].

Легирование делает неравновесные структуры мартенсита и аустенита более устойчивыми, а все термически активируемые процессы идут медленнее и при более высоких температурах. Поэтому эффекты от действия ПХО на высоколегированные стали Р6М5 и Х12М отличаются от наблюдаемых в углеродистых и малолегированных сталях. Отмечаемое повышение макро- и микротвердости в сочетании с изменением вида дифрактограмм свидетельствует о преимущественном развитии процессов отпуска, сопровождающихся вторичным твердением - выделением вторичных карбидов из мартенсита и аустенита. Наличие рефлекса (111) аустенита наблюдается перед ПХН как в стали ХВГ, так и в сильнолегированной Р6М5. В эталонном образце отожженной ферритной стали этот рефлекс отсутствует. Напыление в течение 15с в стали ХВГ и 30-45с в стали Р6М5 вызывает более четкое оформление этого рефлекса, что связано с появлением фиксируемых новых количеств остаточного аустенита, а это возможно лишь в результате повторной закалки. Увеличение экспозиции до 30-45с приводит к уменьшению высоты и даже полному исчезновению аустенитного максимума (111) и появлению карбидных рефлексов в стали ХВГ, что свидетельствует о полном распаде аустенита на феррито-карбидную смесь. В стали Р6М5 с более легированным аустенитом последний сохраняется и при увеличении времени напыления до 45 с, но наряду с этим появляются рефлексы выделяющихся из твердых растворов вторичных карбидов, которых значительно больше, чем в стали ХВГ. Упрочнение от появления мелкодисперсных карбидов превалирует над другими эффектами: уменьшением твердости при понижении уровня внутренних напряжений, появлением мягкой аустенитной фазы плазменной закалки, полигонизационными и рекристаллизационными процессами в ферритной матрице.

Таким образом, сопоставление результатов металлографического и рентгеноструктурного анализа с данными по микротвердости показали, что плазмохимическое нанесение износостойких пленок на основе карбида кремния в нетеплостойких углеродистых и слаболегированных сталях 45, 40Х, У8А, ХВГ со структурами мартенсита отпуска и квазиэвтектоидов (троостита, сорбита) приводит к уменьшении макротвердости, тогда как в сталях карбидного класса Р6М5 и Х12М она возрастает на 2-4 HRC.

Следует отметить неоднозначный характер структурно-напряженного состояния сталей после плазменного воздействия. По-видимому, это связано с многофакторностью и разнообразием процессов, протекающих в поверхностных слоях. Меняя параметры плазменного потока (мощность, выделяемую в разряде, расстояние от плазменного сгустка, время экспозиции), можно добиваться достаточного уровня твердости поверхности инструмента, что в совокупности с полученной пленкой карбида кремния дает высокий эффект износостойкости.

Производственные испытания инструмента, обработанного по описанной технологии (резцов, сверл, фрез, протяжек), показали, что их износостойкость возрастает в 2-2,5 раза.

ЛИТЕРАТУРА

1. Патент РФ № 2100870. Способ формирования пленки карбида кремния на подложке / В.М. Рубинштейн, В.Б. Тригуб, И.С. Суровцев, В.И. Петраков, Н.П. Толоконников. – Опубл. 27.12.97.
2. Макеева Н.Н., Суровцев И.С., Терехов В.А., Анохин В.З. Пленки карбида кремния, полученные в плазме высокочастотного разряда // Изв. АН СССР. Неорган. материалы. – 1987. – № 6. – С. 924–926.
3. Тригуб И.Б., Орлова А.И., Лихолет И.В., Рубинштейн В.М. Влияние плазмохимического напыления на структуру и свойства инструментальных сталей пониженной теплостойкости. // Физика и химия обработки материалов. – 1991. – № 4. – С. 95–101.

SELECTION OF THE WELDING TECHNOLOGY OF RELIABLE JOINTS USING GMAW PROCESS

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Abstract

Determing of welding regime, besides to choosing welding method, welding joint and welding groove, filler metal and welding equipment, calculating of energo-technological parameters, implies preliminary estimate of the base metal weldability. That estimate can be resumed as evaluation of resistance to cracks in the base metal during welding procedure, as well as determing prior and the follow-up thermal treatment of base metal if needed. In this paper it will be given a procedure on determing optimized shielded gas welding technology of the high reliable assemble built-up of the massive pipe and pipe cover.
Key words: *weldability, preheating, welding technology, gas metal arc welding, cracks, hardness, microstructure*

1. INTRODUCTION

As can be seen at the drawing (Fig. 1a), the pipe and the cover ought to be welded around the whole perimeter, with the prior prepared groove - detail "A" (Fig 1b).

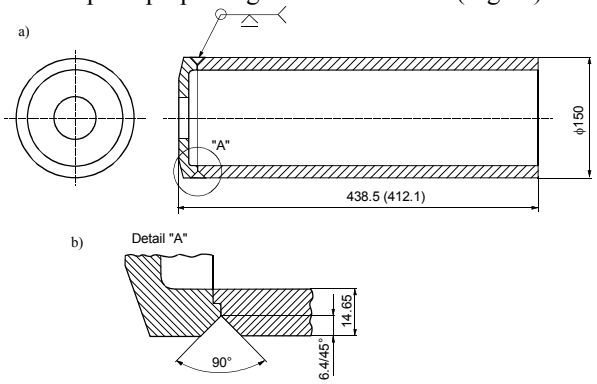

Figure 1 *Welding of the pipe and the pipe cover (a) and the appearance of the groove shape (b)*

2. ESTIMATE OF THE BASE MATERIALS WELDABILITY

Prior to selection of the welding procedure, technology and optional thermal treatment (the previous one and follow-up one), it is necessary to estimate weldability of the base material. Chemical composition and mechanical properties of the base metal St 52.0, obtained by the chemical and mechanical analysis, are given in the next table.

Content of individual elements, %					
C	Si	Mn	P	S	Al
0.17	0.45	1.33	0.008	0.009	0.028
Mechanical properties					

R_{eH}, *MPa*	R_m, *MPa*	A_5, %
377	577	30.8

Based on the chemical analysis of the welded steel, one can say that here we deal with the fine grain C-Mn steel of the increased strength and the ferrite-perlite structure [1].

2.1 Chemically equivalent carbon

Chemically equivalent carbon, for this type of steel is calculated according to expression:

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}, \%$$

Steels with CE > 0.45% are considered as conditionally weldable (the applications of the prior and the follow-up thermal treatments, preheating and relaxation are necessary), while steels with CE ≤ 0.45 % are considered as good weldable. For the given steel we have CE=0.392% < 0.45%. Thus, according to this criterion, this steel possesses good weldability [1, 2].

2.2 Parametric equations for estimation of proneness of steel to cracks

2.2.1 Parametric equations of cold cracks

For estimate of the sensitivity to cold cracks of the C-Mn steels with the yield strength from 272 to 870 *MPa*, we use equations which take into account the chemical composition of the base metal, content of the diffused hydrogen and stiffness or thickness of the welded layer.

According to **Czech sources** [1] the following equations are used:

$$P_{hp} = P_{CM} + \frac{K}{40000} + 0.015 \cdot \log\frac{H}{2.77}, za\ \mathrm{K} \le 1300$$

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$$P_{hp} = P_{CM} + \frac{K}{40000} + 0.075 \cdot \log\frac{H}{2.77}, za\ \mathrm{K} > 1300$$

$$P_{CM} = C + \frac{Si}{30} + \frac{Mn + Cu + Cr}{5} + \frac{Ni}{60} + \frac{Mo + V}{15} + 5B$$

where: K=70·s - the stiffness factor of the butt joint,
s - thickness of the welded material, *mm*,
H- content of the diffused hydrogen in the joint metal, $cm^3/100g$.

The welded joint for which the value $P_{hp} \leq 0.24$ is obtained is considered as resistant to cold cracks, while for the values $P_{hp} > 0.24$ the preheating is necessary at:

$$T_p = 1600 \cdot P_{hp} - 308,^0\ C\cdot$$

With assumption that the welding will be performed as the metal arc gas welding (80% Ar + 20% CO_2) with the dry and clean wire, we adopt H=3 *ml/100g*. Maximum thickness of the welded part is s=14.65 *mm*.

Thus: K=70·s=70·14.65=1025.25<1300,

P_{CM}=0.2515, P_{hp}= 0.278, i.e. **T_p= 136ºC**.

According to analogy with the formula of equivalent carbon, the Japanese **authors** [1] proposed the indicators of low carbon steel sensitivity to forming the cold cracks during welding:

$$P_C = P_{CM} + \frac{s}{600} + \frac{H}{60}$$

where:

$$P_{CM} = C + \frac{V}{10} + \frac{Mo}{15} + \frac{Mn + Cu + Cr}{20} + \frac{Ni}{60} + 5 \cdot B$$

,

s- the steel thickness in *mm*,

H- content of the diffused hydrogen in $cm^3/100g$.

If $0.25 < P_C < 0.40$, at medium weld heat input, the preheating is necessary up to the temperature:

$$T_p = 1440 \cdot P_C - 392,^0\ C\cdot$$

it gives us: P_{CM}=0.2365, P_C=0.3109, namely **T_p= 56ºC**.

The preheating temperature for conditionally weldable steels, can be calculated using the **Seferian formula**:

$$T_p = 350 \cdot \sqrt{[C] - 0.25}\ ,\ ^oC$$

$$[C] = [C]_h + [C]_s = [C]_h(1 + 0.005 \cdot s)$$

$$[C]_h = C + \frac{Mn + Cr}{9} + \frac{Ni}{18} + \frac{7 \cdot Mo}{90}$$

it gives us: $[C]_h$=0.317, [C]=0.34, namely **T_p=105ºC**.

For the test welds, a higher preheating temperature than the calculated one was adopted: **T_{pmax}=150ºC**.

2.2.2 Parametric equations of the hot cracks

According to **Russian references** [1], sensitivity to forming hot cracks can be estimated with help of the modified equivalent carbon:

$$CE_m = C + 2S + \frac{Si - 0.4}{10} + \frac{Mn - 0.8}{12} + \frac{Ni}{12} + \frac{Cu}{15} + \frac{Cr - 0.8}{15}, \%$$

Steels that have CE_m > 0.45% has sensitivity towards forming the hot cracks (HCS).

Japanese authors derived the following expression for estimating the sensitivity towards forming hot cracks:

$$H.C.S. = \frac{C \cdot (S + P + \frac{Si}{25} + \frac{Ni}{100}) \cdot 10^3}{3 \cdot Mn + C + Mo + V}$$

The carbon steels are often sensitive to those cracks for H.C.S. > 4, and steels of increased strength for H.C.S. > 2 for thin sheets and H.C.S. > 1.6 for thick sheets.

According to the previous expressions, one obtains **CE_m= 0.237 < 0.45** and **H.C.S.= 1.49 < 1.6**, what means that the base metal St 52.0 is resistant to hot cracks. Low content of P and S (<0.015%) approves that fact.

3. SELECTION OF THE WELDING PROCEDURE AND TECHNOLOGY

3.1 Introduction

We selected the metal arc gas welding with gas mixture (80% Ar + 20% CO_2), at the semi-automatic numerical machine for circular welding. In order to fix the pipe cover for the pipe, three joints at three points at 120º angles were made (Fig. 2). Joining was done with CO_2 shield manually (wire diameter ø1.2 *mm* and current intensity I≈ 200 *A*), and the joints' length was about 20 *mm*. After cooling down to the room temperature, the beginnings and end on all three joints were ground.

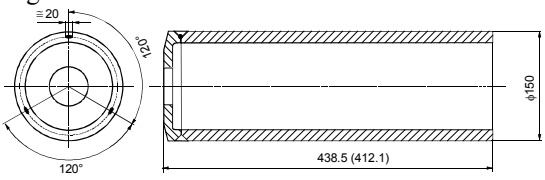


Figure 2 *Scheme of the joints' positions*

3.2 Calculation of the welding parameters

Technological parameters of metal arc gas welding were calculated according to the following method [1]:

1. Groove area: $A_{zl} = 2 \cdot P_{\Delta} = 2 \cdot \frac{6.4^2}{2} = 40.96\ mm^2$
2. Joint area: $A_{\check{s}} \approx 1.3 \cdot A_{zl} = 1.3 \cdot 40.96 = 53.248\ mm^2$
3. Single joint layer area: $A_z \approx 25\ mm^2$
4. The single layer mass per length unit:

$$M = \rho \cdot A_z \cdot L = 7.85\frac{g}{cm^3} \cdot 0.25cm^2 \cdot 1cm = 1.9625g$$

5. Quantity of the deposited material per time unit:

$$m_{1.6} = 0.64 + 0.55 \cdot M - 0.055 \cdot M^2 \approx 1.51\,{}^{g}\!/_{s}$$

6. Welding speed:

$$v_z = \frac{m \cdot 6000}{A_z \cdot \rho} = \frac{1.51 \cdot 6000}{25 \cdot 7.85} = 46\,{}^{cm}\!/_{\min}$$

7. Wire melting (addition) speed:

$$v_t = \frac{0.012732 \cdot A_z \cdot v_z}{d^2} = \frac{0.012732 \cdot 25 \cdot 46}{1.6^2} = 5.7\ {}^{m}\!/_{\min}$$

8. Welding current intensity:

$$I_{1.6} = 378 \cdot \log v_t + 26 = 378 \cdot \log 5.7 + 26 \approx 312A$$

9. Operating voltage:

$$U = 14 + 0.05 \cdot I = 14 + 0.05 \cdot 312 \approx 30\ V$$

10. Weld heat input:

$$q_l = \frac{U \cdot I}{v_z} \cdot \eta = \frac{30 \cdot 312}{0.768} \cdot 0.85 = 10359 \ {}^{J}\!/_{cm}$$

11. Welding depth:

$$\delta = 0.3 \cdot 0.00537 \cdot \sqrt{q_l} = 0.3 \cdot 0.00537 \cdot \sqrt{10539} = 0.164 cm$$

12. Shielding gas type: mixture (80% Ar + 20% CO_2)
13. Shielding gas flow: $q \approx 20$ *l/min*

Besides the enumerated parameters, the following should be considered: length of the pulled portion of the electrode wire, position of the wire electrode with respect to the joint plane, distance of the gas nozzle from the working piece surface, polarity of the wire electrode, welding position, variably inductivity, etc.

The calculated welding parameters are the initial ones for selecting the welding regime. The same are then compared with ones proposed from experience and, eventually, the correction of some of them is done. After testing of the realized joints, welding parameters that produce the best results are adopted.

3.3 Selection of the filler metal

As the filler metal is used the copper platted steel wire VAC 60, ø1.6 *mm* (JUS C.H3 Č3203; DIN 8559/94 SG-2-CY 4233; AWS A5.-18-79 ER 70S-6) aimed for welding in the gas shielded atmosphere. According to the manufacturer's recommendation it is also convenient for welding non-alloyed and low-alloyed constructive steels with $R_m \leq 590$ *MPa* (boiler's and ship's thin sheets, etc). Mechanical properties of the clean welding layer and chemical composition of the wire are given in the following two tables.

$R_{p0.2}$, *MPa*	Rm, *MPa*	A_5, %	ISO-V (-40 ºC), *J*
410÷490	510÷590	22÷30	> 47

Welding current: DC (E+)

C	Si	Mn	P	S
0.08	0.90	1.5	<0.025	<0.025

3.4 Selection of the welding technology and control of the realized joints

Prior to commencing the welding, for both the test and for real ones, the circular radial deviation of each working piece was checked (Fig. 3a). This deviation was within the range of 0.1 to 0.2 *mm*, what was considered as technologically acceptable.

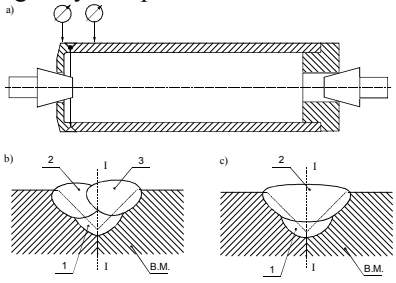


Figure 3 *Scheme of the a) circular radial deviation, b) continuous three-passes and c) two-layers welding*

Prior to welding, the joint pieces were degreased by washing with the adequate cleaner, and then dried.

In order to select the optimum technology, numerous test weldings were performed with the calculated parameters, under the conditions with the preheating (T_p= 150ºC) and without it, in 3-passes (Fig. 3b) and 2-layers (Fig. 3c).

From the test joints, the metallographic ground test samples were prepared, at which the micro hardness was measured (HV1) and the microstructure was read off individual zones of the welded layer (see next table).

passes		3	2	3
$T_p \approx$		150°C	20°C	20°C
Max. and min. hardness (HV1) and read off microstructure of characteristic zones	JOINT	221÷251 HV1 Small grain Vidmansteten	205÷217 HV1 Small grain Vidmansteten	201÷234 HV1 Small grain Vidmansteten
	$HAZ_{3,2,1}$ $HAZ_{2,1}$	210÷227 HV1 Interphase + Tempered martensite	205÷214 HV1 Interphase + Tempered martensite	219÷229 HV1 Interphase + Tempered martensite
	B.M. (pipe)*	201÷210 HV1 Lamellar pearlite-ferrite	201÷210 HV1 Lamellar pearlite-ferrite	201÷210 HV1 Lamellar pearlite-ferrite

* For pipe cover microstructure is ferrite-pearlite.

Hardness distribution and appearance of microstructures at 2-layers and 3-passes welding without preheating are shown in Figures 4 and 5 (direction I-I, fig. 3b i 3c).

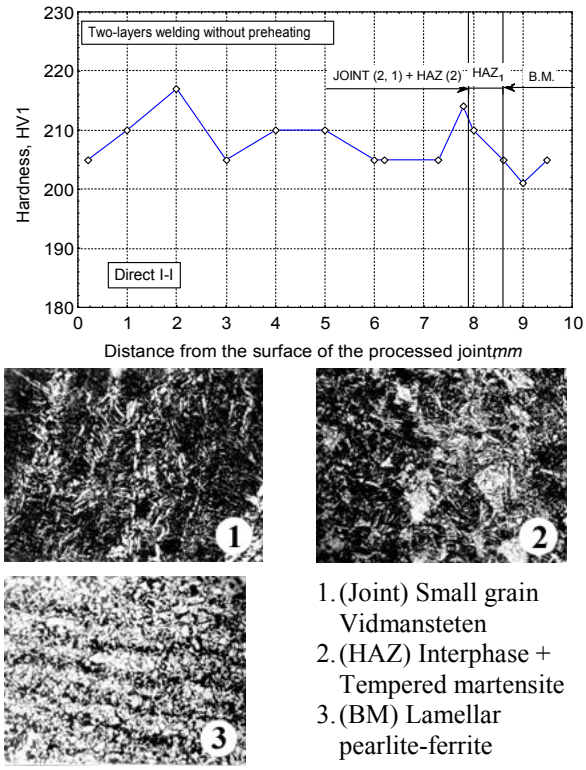
By analysis of obtained results, one can conclude that no significant differences were noticed in measured hardness and read off microstructures of individual zones in conditions of welding with and without preheating.

We decided to apply the three-passes welding procedure, primarily due to large angle of the groove opening and due to necessary follow-up machining of the joint faces.

Passes were done immediately one after another (Fig. 3b). The capping pass 2 relaxes the root pass 1, and the capping pass 3 relaxes the root pass 1 and partially pass 2, what gives the better microstructure, the possible brittle zones are avoided, and the level of the residual stresses is decreased. With this way of welding the necessary excess weld metal is formed, which must be removed by machining according to the constructional requirements.

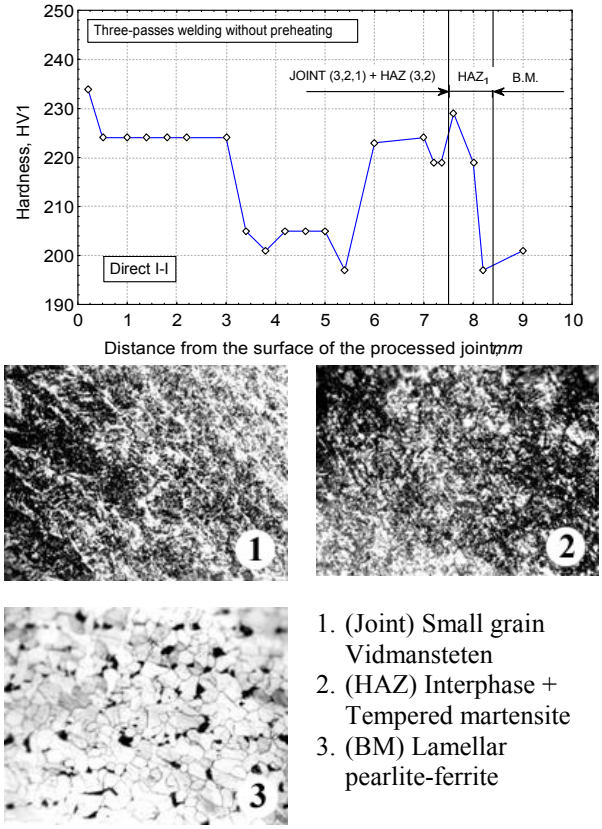
During welding the energetic parameters (I, U i v_z) were monitored continuously, i.e. weld heat input was inside limits q_l= 9500÷10500 *J/cm*. This power provides for necessary welding, hardness, microstructure and corresponding output mechanical properties.

Experimental investigations had confirmed that this is of good weldability, so neither prior nor follow-up thermal treatments are necessary.



1. (Joint) Small grain Vidmansteten
2. (HAZ) Interphase + Tempered martensite
3. (BM) Lamellar pearlite-ferrite

Figure 4 *Two-layer welding*



1. (Joint) Small grain Vidmansteten
2. (HAZ) Interphase + Tempered martensite
3. (BM) Lamellar pearlite-ferrite

Figure 5 *Three-passes welding*

For the sake of additional checking whether the adopted procedure and welding regime provide for the convenient structure and mechanical properties (optimum toughness, corresponding hardness and microstructure), besides already described experimental method, the TTT diagram was analyzed - for steel St 52.0. The characteristic cooling time between 800 and 500°C ($t_{8/5}$) calculated according to empirical formula and entered into the TTT diagram enables estimates of structure and reading off hardness and toughness of the HAZ. With this checking, the agreement was confirmed of the estimated (expected) and experimental results [3, 4, 5].

Besides the visual control and conducted parallel metallographic investigations, ultrasonic defectoscopy was a requirement and was performed by the accredited laboratory for nondestructive testing. During all these investigations, no faults were noticed, either external or internal, in the welded joints.

4. CONCLUSION

According to the conducted investigations in determing optimal welding technology on high quality joints, the following conclusions can be drawn:

- the base metal is from the noble steels class and its weldability is good,
- this steel is not prone to forming of cracks and brittle zones during welding by melting,
- welding can successfully be performed by metal arc gas welding procedure with the proposed technology,
- the three-passes welding is necessary due to construction of the given type of groove (too large angle of the groove opening),
- experimental investigations did not show any undesirable structures and zones of increased hardness,
- neither prior nor follow-up thermal treatments are necessary.

5. LITERATURE

1. Jovanović, M., Adamović, D., Lazić, V.: *Technology of welding-The handbook*, Independent authors' edition, Kragujevac, 1996., (First edition).
2. Milosavljević, M., Radojković, M., Kuzmanović, B.: *Fundamentals of Steel Structures,* Seventh edition, Gradjevinska knjiga, Belgrade, 1986.
3. Lazić, V., Josifović, D., Jovanović, M.: *Validity of some formulae for calculation of cooling time during welding,* Zavarivač, 40(2), 1995, Belgrade, pp. 89-94.
4. Lazić, V., Jovanović, M., Adamović, D., Ratković, N.: *Improvement of the welding procedure of the fire truck rear axle semi housing assembly*, Mobility & Vehicles Mechanics, International Journal for Vehicle Mechanics, original scientific paper, Engines and Transportation Systems, Vol. 30 No 1, Kragujevac, March 2004, pp. 45-57.
5. Jovanović, M., Lazić, M., Adamović, D., Ratković, N.: An estimate of accuracy of empirical formulae for calculating the cooling time (t8/5) after hard-facing, HM'02, Kraljevo, 27-30 June 2002., pp. B.21-B.26

ВОЗМОЖНОСТИ ВАКУУМНОЙ ФОРМОВКИ ДЛЯ ВЫРАБОТКИ ФОРМООБРАЗУЮЩИХ ИНСТРУМЕНТОВ

Рангел К. Рангелов, Деньо А. Георгиев, Крум Л. Петров и Боряна Д. Съйкова[1]

В данном докладе показаны результаты исследовании металлических литейних форм, выработанных различными способами. В лаборатории литья металлов в ТУ – София разработана обмазка для кокилей. В докладе показана последовательность выработки деталей посредством вакуумной формовки.

вакуумная формовка, формообразующие инструменты, кокиль

Процесс вакуумной формовки освоен, исследован и усовершенствован в лаборатории литья металлов при ТУ – София и является методом, на основе которого разработаны технологии литья для успешной отливки формообразующих инструментов – моделей литья из металла, ящиках для стержней, кокилей, прессформ, шприцформ для экспандировки полистирола, матриц вулканизации резины и др.

В данном докладе показаны результаты исследований:

- кокилей из чугуна, выработанных различными методами,
- матриц из алюминия для вулканизации резины.

I. КОКИЛИ

Рабочие поверхности кокилей, как известно, вырабатывают путем литья, механической, электрофизической обработки, сварки, штамповки и комбинирования этих способов. Самое широкое распространение получило литье (во всех его разновидностях) с последующей обработкой резанием (или же слесарской обработкой), причем – со стремлениемк минимальнаму обьемудоводки [1]. Ввиду того, что у материалов для кокилей чаще всего ниская теплопроводность, в них появляются внутренние напряжения, вызванные неравномерным нагревом по сечению кокил [2]. Кроме того, поверхность, соприкосающаяся с жидким металлом, подвергется сильному перегреву и это ускоряет процессы коррозии и других химических взаимодействий. Здесь проделано сравнительное исследование появления и распространения трещин на рабочей поверхности кокилей, выработанных вакуумной формовкой [3], посредством литья в фурановых формах и путем механической обработки. Стойкость кокилей оценивают числом и суммарной длиной полученых видимых трещин вследствие термических циклов, реализованных погружением в жидкий чугун. Результаты представлены на рис.1 и рис.2.

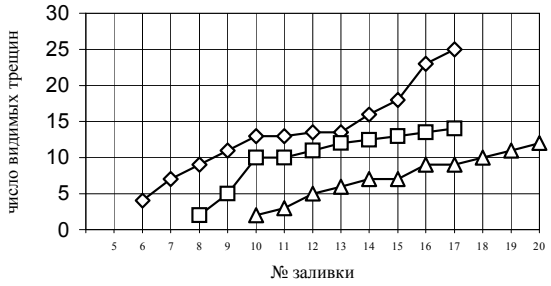


Рис. 1

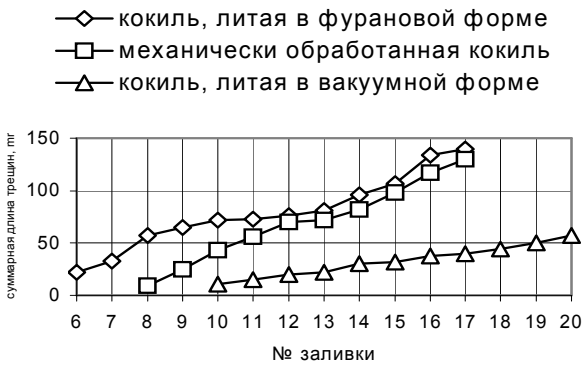


Рис. 2

Сравнительное исследование показало, что устойчивость кокили, выработанной в вакуумированной форме во много раз выше той кокилей, выработанных иными способами. При механически обработанной кокиле этот результат провокируется самой механической обработкой – при резании удаляется самый наружный слой кокили (так называемая литейная корка), причем графитные включения из внутренных слоев, выходят на поверхность. При кокиле, литой в фурановой форме, причиной слабого результата может быт указана повышенная шероховатость поверхности, что ведет к большей площади топлообмена, из-за чего она

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работает в более тяжелам термическом режиме по сравнению с литой в вакуумированной форме, как и механически обработаная, что логически сокращает ее жизнь.
Хорошие эксплуатационные качества, вместе с быстрой вырботкой и ниской ценой кокилей, литых в вакуумированных формах, является причиной их успешного применения в практике, рис. 3.

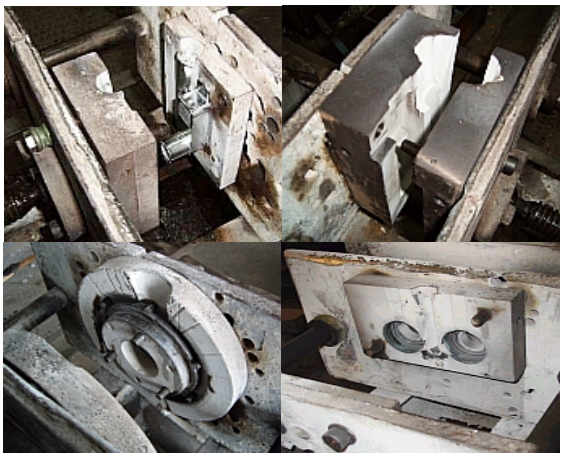

Рис. 3

Качество получаемых в кокилях отливок большой степени зависит от исспользованных обмазок и покрытий [4], [5].

В лаборатории литья металлов при ТУ – София разработана обмазка для кокилей из чугуна на основе жидкого стекла и аморфного двуокиса кремния. Чтобы остановить прочность покритий относительно металлической поверхности, проведен экперимент, дающий сравнительные оценки. Прочность определяется сопротивлением SiC. Струя падает с высоты 500 mm на расположенную под углом 450 чугунную плиту с теплоизоляционным покритием, пока обмазка не сотрется и не откроется металлическая поверхность в зоне с диаметром приблизительно двух милиметров. Песок, потраченный для вскрытия металлической поверхности, собирается и взвешивается. В результате проведенных экспериментов было остановлено, что обмазку состаящую из 20 % двуокиса кремния, 15 % жидкого стекла и 65 % воды, можно с успехом применять при процессе кокильного литья сплавов алюминия.

2. МАТРИЦЫ ДЛЯ ИЗДЕЛИЙ ИЗ РЕЗИНЫ

Интересной инженерной задачей является выработка литой технологической оснастки для вулканизации резиновых протекторов для регенерирования автомобильных шин.
На рис. 4 показана последовательность выработки деталей посредством вакуумной формовки.

Рис. 4

По отношению к точности и жесткой повтаряемости размеров и качества рабочей поверхности предъявляются серьезные требования.

Размеры A, B и C (рис. 5) выработанных восемнадцати отливок для сегмента “Z1” и десяти отливок для сегмента “Z2”, были измерены с точностью до 0,05 mm. Модели из гипса имеют следуюших размеров:
Z1 : A=225.30, B= 165.10, C=122.60,
Z2 : A=224.60, B=151.70, C=72.80.

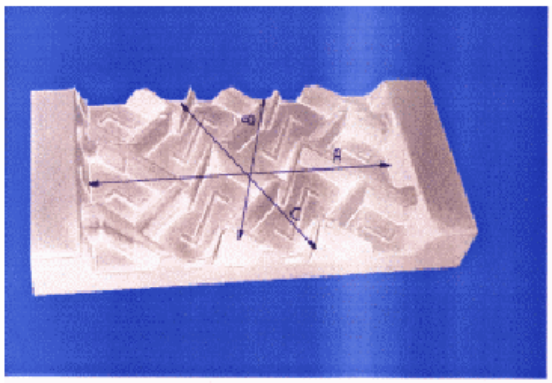

Рис.5

олученные результаты даны в таблице 1 и таблице 2. Полученные данные насчет размеров A, Ви C, были подвергнуты статистическо обработке и анализу [6]. Расчетные значения представлени в таблице 3.

Необходимо отметить, что при всех размерах погрешности (разница между найбоьшим и найменьшим значениями) не выше 0,1 %. Сравнение расчетных значений соответствующих размеров моделей и отливок (табл. 1 и 2) дает возможность определить литьевое сжатие исследованных отливок (табл. 4).

Необходимо отметить, что оставновленное литьевое сжатие в границах, указанных в литературе [7], где касатеьно использованного сплава они составляют 1,2 □ 1,3 %.

Шероховатость рабочих поверхностей отливок была измерена аппаратурой Perthem, модели Perthometer C50.

Таблица 1 Размеры отливок Z1

№	A, mm	B, mm	C,mm
1	222,45	163,05	121,1
2	222,5	163,15	121,05
3	222,4	163,15	121,15
4	222,45	163,1	121,1
5	222,5	163,1	121,1
6	222,45	163,15	121,15
7	222,4	163,1	121,15
8	222,4	163,1	121,1
9	222,45	163,15	121,05
10	222,5	163,05	121,1
11	222,4	163,1	121,05
12	222,45	163,15	121,15
13	222,45	163,1	121,15
14	222,5	163,1	121,1
15	222,5	163,15	121,1
16	222,45	163,1	121,15
17	222,4	163,05	121,15
18	222,5	163,05	121,05

Полученные данные показывают что отливки, выработанные в лаборатории литья металов при ТУ – София методом вакуумной формовки, характеризуются высокой точностью и качеством поверхности. Шероховатость отливок соответствует литью в кокилях, точному литью и даже литью под давлением.

Таблица 2 Размеры отливок Z2

№	A, mm	B, mm	C, mm
1	221,85	149,8	71,95
2	221,8	149,75	71,9
3	221,85	149,8	71,85
4	221,75	149,8	71,95
5	221,75	149,7	71,95
6	221,8	149,75	71,95
7	221,85	149,75	71,9
8	221,8	149,7	71,95
9	221,8	149,8	71,85
10	221,85	149,8	71,95

Таблица 3 Данные статистической обработки

№	A, mm		
	Acp, mm	σ_1	σ_2
Z1	222.45	0.0028	0.0015
Z2	221.81	-0.005	0.0022
№	B, mm		
	Bcp, mm	σ_1	σ_2
Z1	163.10	0.0055	0.0014
Z2	149.76	0.005	0.0015
№	C, mm		
	Ccp, mm	σ_1	σ_2
Z1	121.11	-0.0017	0.0015
Z2	71,92	0.0	0.0016

Таблица 4. Литьевое сжатие отливок

№	A, %	B, %	C, %
Z1	1.28	1.23	1.23
Z2	1.26	1.30	1.22

В таблице 5 показаны, измеренные значения Ra, Rz и Rmax отливок.

Таблица 5 Шероховатость поверхностей

Сегмент Z1			Образец- мостра			Кокильная отливка		
Ra	Rz	Rmax	Ra	Rz	Rmax	Ra	Rz	Rmax
4.7	25.4	37.9	7.2	40.6	57.3	6.7	57.1	66.5

1. Бураков С. под редакцией Вейника А. И., Литье в кокилях, Машиностроение, М., 1980.
2. Скобло Ю., Исследование механизма разрушения кокилей разной тепловой нагруженности, Автореферат, Донецк, 1977.
3. Ангелов Г. и др., Вакуумно формоване, София, Техника, 1984.
4. Длъгников И. и др., Покрития за леярски форми, С., Техника,1985.
5. Рангелов Р., Обмазки за метални леярски форми, Национална научно-техническа конференция, Ловеч, 2002.
6. Оболенцева Ф., Точность и качество поверхности отливок, Москва, 1962.
7. Славов Р., Манолов М., Атанасова В., Наръчник по леене на цветни метали и сплави, София, Техника, 1976.

ПЛАСТМАССОВЫЕ МОДЕЛИ, ИЗГОТОВЛЕННЫЕ В ВАКУУМНЫХ ФОРМАХ

инж. Д.Алипиев

В работе рассматривается технология изготовления пластмассовой литейной оснастки вакуумной формовкой. Кроме того, на оснований эксперимента предложен способ определения границ износостойкости, позволяющий оценивать эксплуатационные характеристики моделей.

пластмассовая литейная оснастка, вакуумная формовка, износостойкость

Технология выработки пластмассовых моделей в вакуумированных формах (рис. 1 и 2) создана в Техническом Университете - София в прошлом десятилетии. Она ведет свое начало из V-процесса [1], с той разницей, что в форму выливают модельную смесь вместо металла.

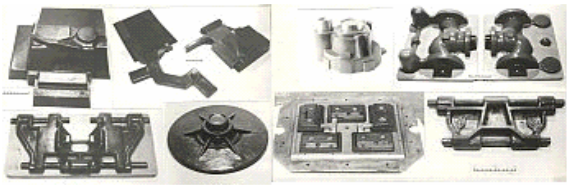

Рис.1

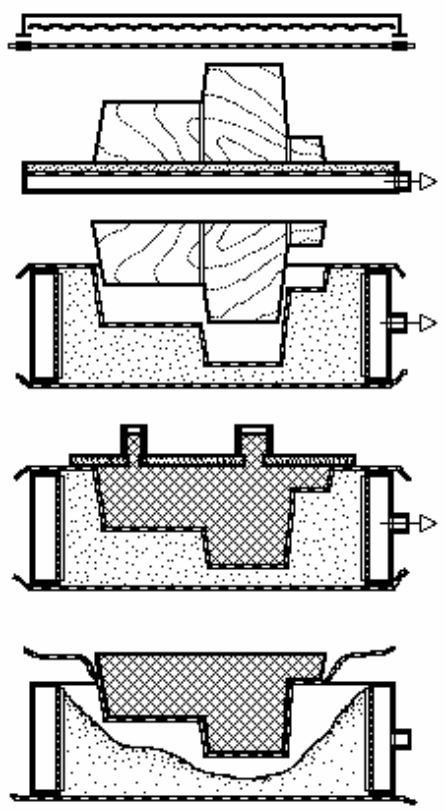

Рис.2

Модели, сделанные в вакуумированных формах, сохраняют положительные стороны моделей, полученных в пластмассовых формах [2]. Преимущество технологии с применением вакуумированных форм состоит в быстроте процесса, так как в выработанных за короткий срок формах получаются множество моделей из одной модели-эталона. Кроме того, модели-эталоны могут быть выработаны из материалов небольшой прочности, так как вынуть их из формы не представляет собой никакую проблему.

Слабые стороны технологии состоят в том, что для ее реализации необходимы специальные сооружения и она зависима от энергийных источников.

Из указанных особенностей следует, что было бы хорошо использовать обе технологические системы совместно, когда это возможно.

Несмотря на технологию их выработки, пластмассовые модели должны обладать повышенной износостойкостью. В различных публикациях и стандартах износостойкость моделей определяется в весьма широких границах. Так, Heine [3] например, указывает следующие значения эпоксидных моделей: 20-30000 при прессовании, 1500-5000 при пескометной формовке и 9-15000 при пескострельной выработке форм. Русский стандарт 19505 регламентирует где-то 2000 и 4000 циклов для эпоксидных моделей при формовке вручную, и 25-35000 при машинной формовке. Golding [4] указывает 30-60000 формований для моделей из полиуретановой смолы, причем он не выясняет условия эксплуатации, в то время Bailey [5] - 50000 циклов при высокопрессовой формовке.

Это разнообразие данных проистекает из влияния важных факторов, таких, как геометрии моделей, состава модельной смеси, способа формовки и др.

Здесь представлен способ определения изнашивания пластмассовых моделей, причем для его

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иллюстрации использованы четыре состава, выработанные в вакуумированных формах:

1 - Araldit 404, 2 - Ureol 6414 A/B + Fe пыль,
3 - Araldit 410, 4 - АП1 + Fe пыль.

В первую очередь, образцы (рис.3) изнашиваются посредством крутки в песке (рис.4). После "прокрутки" некоторого расстояния измеряется изменение размера А (Ао=60 мм).

Рис.3

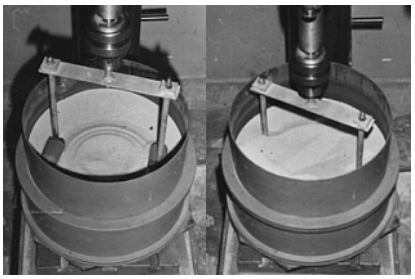

Рис.4

В таблице 1 показаны пройденные метры до уменьшения размера А на один милиметр. В таблице 2 отражены расчетные коэффициенты К отношения любого из составов к самому износостойкому из них, при соответствующем уровне изнашивания.

Таблица 1

	-0.2	-0.4	-0.6	-0.8	-1.0
1	21798	30447	36300	41045	45078
2	18683	27055	32412	36835	41094
3	15685	23779	28531	32790	37149
4	10518	19482	25478	29253	33027

Таблица 2

	-0.2	-0.4	-0.6	-0.8	-1.0
К2/1	.857	.889	.893	.897	.912
К3/1	.720	.781	.786	.799	.824
К4/1	.483	.640	.702	.713	.733

Дальше следует изнашивание новых образцов лишь из наиболее износостойкого состава посредством выстреливания песка и на формовочную смесь (рис.5).

Рис.5

Число выстрелов (6000 реально проведенных, как и экстраполяцией) и соответствующее уменьшение размера А, показаны в таблице 3.

Таблица 3

	-0.2	-0.4	-0.6	-0.8	-1.0
песок	3267	4450	5333	6074	6815
смесь	5556	7778	10000	12222	14444

В конечном итоге определяется износостойкость составов, неподвергавшихся выстрелам. Это происходит посредством умножения коэффициентов К на число выстрелов, реально достигнутых наиболее износостойким составом касательно соответствующего уровня изнашивания. В таблице 4 отражены результаты выстрелов песком (граница n), а в таблице 5 - выстрелов формовочной смесью (граница N).

Таблица 4

	-0.2	-0.4	-0.6	-0.8	-1.0
n1	3267	4450	5333	6074	6815
n2*	2800	3954	4762	5451	6212
n3*	2351	3475	4192	4852	5616
n4*	1578	2848	3744	4331	4995

Таблица 5

	-0.2	-0.4	-0.6	-0.8	-1.0
N1	5556	7778	10000	12222	14444
N2*	4762	6911	8929	10969	13168
N3*	3998	6074	7860	9764	11904
N4*	2684	4978	7020	8714	10587

Граница n определена при изнашивании посредством сильно абразивного материала – песка и посредством выстрелов – одного из самых абразивно действующих методов уплотнения. Так как механическое уплотнение литейных форм песком без связувющих веществ в практике не существует, граница n является условной. Граница n является возможно самой ниской износостойкостью, которую пластмассовые модели, работающие в реальных условиях, должны были бы переходить.
Граница N определена при часто применяемых в практике условиях – сырой песчано-глинистой формовочной смеси и выстреливании ее самой. Если принять, что состав этого вида смеси не оказывает существенного влияния на изнашивание, граница N является реально и обязательно достижимой износостойкостью при выработке литейных форм посредством выстреливания. Эта гарантийная эксплуатационная долговечность касается еще в большей степени выработки литейных форм иными способами с меньшим абразивным воздействием.
Так, с одной стороны, при достижении границы N, контроль за моделями необходимо усилить ввиду ожиданий их возможной смены. С другой стороны,

N может послужить для принятия гарантий производителями литейных пластмассовых моделей касательно срока их использования в конкретных эксплуатационных условиях. Эти два обстоятельства делают границу N полезной для практики.
Данные насчет износостойкости образцов при выстрелах песком и формовочной смесью получаются медленно и с трудом, но после того, как их обнаружить, они могли бы послужить при определении изнашивания (границы n* и N*) неограниченного числа модельных составов, без надобности производить выстрелы для них. Хватит сделать более легкое испытание посредством крутки в песке и вычислить соответствующие коэффициенты.

Сейчас в Техническом Университете -София разрабатывается краткая расчетная программа для определения границ износостойкости для множества модельных составов, данные насчет которых здесь не показаны. Эти составы включают наполнители кварцового песка, корунда и карборунда разной крупностью частиц и в различных соотношениях относительно болгарской эпоксидной смолы АП1.

Изнашивание образцов с теми же составами, но выработанных конвенциональной технологией в пластмассовых формах, так же являются объектом программы. С ее помощью будет возможным определение числа формований, причем лимитирующий изнашивание размер данной модели уменьшается в рамках восьми уровней по 0.2 мм (1.6 мм), или согласно классам точности К1 и К2 DIN1511, и 1-9 ГОСТ 11961, причем дается и соответствующая графическая интерпретация процесса изнашивания.

ЛИТЕРАТУРА

1. Ангелов Г. и др., Вакуумно формоване, Техника, 1984.
2. Ciba-Geigy Prospects, Publ. No 24028, 28145, 35513, 35950.
3. Heine H., Using Patterns Cost Effectively. Part I. Foundry M&T, June 1980, 30-40.
4. Golding J., Process development in plastic tooling, The British Foundryman, Jan. 1983, XIII-XVI.
5. Bailey R., The HMP System: A New Idea in Patternmaking, Modern Casting, July 1983, 22-23.

THEORETICAL-EXPERIMENTAL DETERMINING OF COOLING TIME ($T_{8/5}$) IN HARD FACING

Vukić Lazić, Miroslav Zivković, Dragan Rakić, Milorad Jovanović, Dragan Adamović[1]

Abstract: *This paper investigates the evaluation of accuracy of empirical expressions, i.e. the most favourable methods for calculating the cooling time from 800 to 500°C. The degree of accuracy of time t8/5 is very significant, because it indirectly determines the cooling rate, and consequently the structural changes in heat affected zone (HAZ) for hard faced layers. We evaluated the accuracy of specified expressions on the basis of graphic charts of temperature cycles of HAZ determined either experimentally, by calculations or by numerical methods.*

Key words: *cooling time (t8/5), temperature cycle, temperature field, hard facing, operating power, experimental formulas, finite elements method*

1. INTRODUCTION

At welding and hard facing of low-alloyed and constructional steels, especially tempered ones, it is not sufficient to determine only the technological parameters of hard facing necessary for proper formation of hard faced layers; furthermore, the negative influence of input heat on heat affected zone (HAZ) must be taken into account. The influence of temperature cycle on hardness increase is considered firstly, but sometimes the influence on change of mechanical properties, tendency to cracks, i.e. the appearance of unfavourable structures, residual stresses and strains is considered as well. That is all connected with temperature field around the heat source and temperature change rate from 800-500°C.

2. BASIC EQUATIONS OF HEAT CONDUCTION

The procedure for solving the problem of heat conduction through solid environment by finite elements method will be presented here briefly. Differential equation of energy balance is based on fundamental principle of energy preservation. To be exact, the change of internal energy of material in time unit in elementary volume dV equals the quantity of heat energy accumulated at the same volume in time unit

$$\frac{dQ}{dt} = \frac{dU}{dt}, \qquad (1)$$

where dQ and dU represent changes of heat and internal energy in volume dV in time interval dt.

Conduction of heat through solid bodies was defined by Fourier's Law:

$$\mathbf{q} = -\mathbf{k}\nabla T, \qquad (2)$$

where: **q**-specific heat flux, **k**-die of conduction or conductivity and ∇T-temperature gradient.

By replacement of appropriate expressions and change of expression (2) in energy balance equation (1), we obtain the following differential equation:

$$-\rho c\frac{dT}{dt} + \nabla^T(\mathbf{k}\nabla T) + q_i = 0 \qquad (3)$$

where: ρ-material density, c-specific heat and q_i-effective power of the source.

General solution of differential equation of heat conduction contains undefined functions and constants [1, 2].

In practical problem solving, the solution required for set of temperatures in all points of some space in given observation moment, i.e. temperature field $T(x, y, z, t)$, must be such that it satisfies given initial and limit conditions. There is a single solution for given initial and limit conditions.

The initial conditions are given only for non-stationary problems. They imply that the distribution of temperatures in initial moment, $t = 0$, is known, i.e.

$$T(x, y, z, 0) = f_0(x, y, z), \qquad (4)$$

where $f_0(x, y, z)$ is given function of material points coordinates. Limit conditions in general case can be:

a) given temperature on part

$$T = T_s(x, y, z, t),$$

b) given flux on part

$$q_n = q_n(x, y, z, t),$$

c) given heat transfer (convection) on part

$$q_h = h(T_o - T_s),$$

d) given radiation on part

$$q_r = h_r(T_r - T_s),$$

where S_1, S_2, S_3 and S_4 are parts of surface, T_s is

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temperature on surface, q_n, q_h and q_r are fluxes through surface, T_0 - is temperature of the surroundings, h is transfer coefficient, h_r is radiation coefficient, and T_r - temperature of radiation source.

3. METHODS FOR DETERMINING COOLING TIME ($T_{8/5}$)

3.1 Rikalin's Method

When determining temperature fields at welding (hard facing), differential equation (3) can be transformed and adjusted to given conditions. That refers to various thicknesses of plates (thin or thick) and heat sources (moving or static) [3, 4, 5, 6].

3.1.1 Distribution of temperatures in the case of moving heat source

In this case, instead of static heat source, concentrated heat source moving at constant speed is observed [3, 4, 5, 6].

3.1.1.a Semi-infinite (massive) body

For point moving source of heat which moves along the surface of semi-infinite body at constant velocity *v,* along axis *x,* expression [1, 2, 3, 4] for distribution of temperatures was developed

$$T_{(r,x)} = \frac{q}{2\cdot\pi\cdot k\cdot} \cdot e^{\left(-\frac{v\cdot x}{2\cdot a}-\frac{v\cdot r}{2\cdot a}\right)}, \qquad (5)$$

where: *k*-thermal conductivity, *a*-temperature diffusivity and *r*-radius of given point.
In the case of source moving at high velocity *v*, expression (5) is transformed into the following form:

$$T_{(y,z,t)} = \frac{q}{2\cdot\pi\cdot k\cdot v\cdot t} \cdot e^{-\frac{r^2}{4\cdot a\cdot t}}\cdot \qquad (6)$$

3.1.1.b Thin plate

For the case of moving linear heat source [3, 4, 5, 6] distribution of temperatures is calculated according to expression:

$$T_{(y,t)} = \frac{q}{v\cdot s\cdot\sqrt{4\cdot\pi\cdot k\cdot c\cdot t}} \cdot e^{\left(-\frac{y^2}{4\cdot a\cdot t}-b\cdot t\right)}, \qquad (7)$$

where: *s*-plate thickness, *t*-time and *b*-losses [2, 3, 4].
By calculations and experiments, quasi-stationary state was determined, meaning that temperature cycles and temperature fields in subsequent points recur after specific time intervals, i.e. in line with movement of heat source.
By analysing previous expressions, it can be determined and proved that the form of temperature field depends on: *kind of source*, *velocity* at which it moves, *thickness* of working piece, *effective power of arc* etc. [3, 4, 5, 6, 7, 8].

For calculating the temperature fields and temperature cycles, mathematical software (Matlab, Statistica) was used, and for processing the results the programmes were made in suitable programme languages (Fortran and Pascal). By applying expressions (5, 6 and 7), temperature cycles were calculated and cooling time was determined for proper heat inputs and some points below hard faced layer [5, 6].

3.2 Calculation of cooling time (t8/5) on the basis of empirical formulas

The literature [3, 5, 6, 7, 8, 9] also includes appropriate formulas for calculating the specified time. The following formulas are mainly used:

- Based on *limit* sheet metal thickness ($t_{8/5}$= f(s_{gr})) which separates thin sheet metals from thick plates
- Of *Japanese* authors [3, 5, 6, 7, 8, 9].

3.3 Experimental determining of temperature cycles in hard facing

With the aim of experimental determining of cooling rate (time $t_{8/5}$) in hard facing of steel for forging dies, we prepared special plates-models [5]. They were thermally improved, and then holes were punched for measuring temperatures by means of thermocouples (from class of type K, NiCr - NiAl, diameter 0.24 and 0.4 *mm*) [5, 6].

Papers [5, 6, 8] give explicit survey of results of experimentally determined cooling time $t_{8/5}$, obtained by varying input heat in conditions with and without preheating.

3.4 Numerical method (FEM) of determining cooling time ($t_{8/5}$)

On the basis of Fourier's Law on heat conduction (3), the following can be written:

$$-\int_V \rho c h_I \frac{dT}{dt} dV + \int_V \left[h_I \sum_{j=1}^{3} \frac{\partial}{\partial x_j}\left(k_j \frac{\partial T}{\partial x_j}\right)\right] dV + \int_V h_I q dV = 0 \ , \qquad (8)$$

whereat h_I are interpolation functions for finite element.
Temperature T in element point determined by natural coordinates ξ,η,ζ is given as:

$$\mathrm{T} = \mathbf{HT}, \qquad (9)$$

where $\mathbf{H}$ is vector of interpolation functions, and $\mathbf{T}$ is vector of temperatures in nodes.
The following equation (10) represents the equation of energy balance of finite element in the case of 3D non-stationary heat conduction.

$$\mathbf{C}\dot{\mathbf{T}} + \mathbf{KT} = \mathbf{Q}, \qquad (10)$$

where matrices $\mathbf{C}$ and $\mathbf{K}$ and vector $\mathbf{Q}$ are determined as,

$$\mathbf{C} = \int_V \rho c \mathbf{H}^{\mathrm{T}}\mathbf{H}\ dV \qquad (11)$$

$$\mathbf{K} = \mathbf{K}^k + \mathbf{K}^h + \mathbf{K}^r \qquad (12)$$

$$\mathbf{Q} = \mathbf{Q}^q + \mathbf{Q}^{q_n} + \mathbf{Q}^h + \mathbf{Q}^r . \qquad (13)$$

By adding interpolation matrix $\mathbf{H}$, the proper matrices and vectors can be written in the following form in equation (10):

$$\mathbf{K}^{\mathrm{k}} = \int_{\mathrm{V}} \mathbf{B}^{\mathrm{T}}\mathbf{kB}\mathrm{dV} \qquad (14)$$

$$\mathbf{K}^{h} = \int_{S} h\mathbf{H}^{sT}\mathbf{H}^{s}dS \quad (15)$$

$$\mathbf{K}^{r} = \int_{S} h_{r}\mathbf{H}^{sT}\mathbf{H}^{s}dV \quad (16)$$

$$\mathbf{Q}^{q} = \int_{V} q\mathbf{H}^{T}dV \quad (17)$$

$$\mathbf{Q}^{q_n} = \int_{S} q_{n}\mathbf{H}^{sT}dS \quad (18)$$

$$\mathbf{Q}^{h} = \int_{S} hT_{o}\mathbf{H}^{sT}dS \quad (19)$$

$$\mathbf{Q}^{r} = \int_{S} h_{r}T_{r}\mathbf{H}^{sT}dS \quad (20)$$

3.4.1 Calculation of cooling time $t_{8/5}$

For analyzing the cooling time $t_{8/5}$, two space (3D) models were formed (one for thin, s= 7.4 *mm* and one for thick sheet metals, s= 29 *mm*), which are based on the application of finite elements method (FEM). Since the problem is plane-symmetrical, it is sufficient to consider only one half of the model. .

For modelling of sheet metals, the mesh of eight-node 3D finite elements was used. For thin sheet metal, the mesh of 25476 nodes and 20160 elements was developed, while for thick sheet metal the mesh of 41184 nodes and 35805 elements was formed. It should be remarked that, in analytical calculations, the difference between thin and thick sheet metals is that for thin sheet metals, two-directional heat conveyance is presumed, i.e. $\partial T/\partial s = 0$ is adopted, , while for thick sheet metals, change of temperature by thickness is taken into consideration as well, i.e. $\partial T/\partial s \neq 0$. In both cases, real preheating temperature is employed, as well as dependence of thermal conductivity *k* on temperature (*tab. 1)* and product of specific heat and material density: $c_p \cdot \rho = 4898556\ J/m^3{}^oC$ [10].

Table 1- Thermal conductivity ($k=f(T)$)

T, ^oC	20	350	700	4700
k, W/m^oC	36	38	35	35

Heat is conveyed to sheet metal material according to Gauss' distribution and is given as expression (21).

$$q_2 = q_{2m} \cdot e^{-kr^2} \quad (21)$$

where: q_{2m}-flux at point r=0, k=3-constant, -radius of heat effects [4].

For the realization of this problem, it was necessary to make a particular programme which would provide the given distribution of flux per elements with maintaining the previously mentioned distribution. Therefore, the heat quantity conveyed from electric arc must be distributed per elements in radius , the direction of which corresponds to projection of electrode tip on hard faced part.

3.4.2 Results of calculation of cooling time

The obtained results are presented here by diagrams and by tables. On the basis of diagram (T-t), (Fig. 1 and 2), we can determine cooling time in temperature interval significant for output properties at a particular depth (*x*).

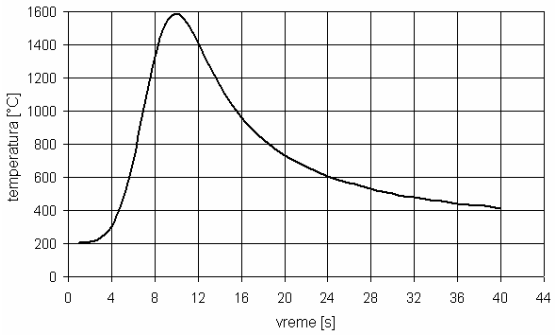

Figure 1 *Temperature cycle of HAZ hard faced layer (s= 29 mm, q_l= 16500 J/cm, v_z= 0.258 cm/s, x= 4 mm, T_p= 204°C)*

In two-dimensional figures (Fig. 3 and 4) temperature fields from which temperatures can be read are given around moving source. The knowledge about those distributions is highly significant for determining material properties in those zones which are exposed to the influence of heat inserted at hard facing.

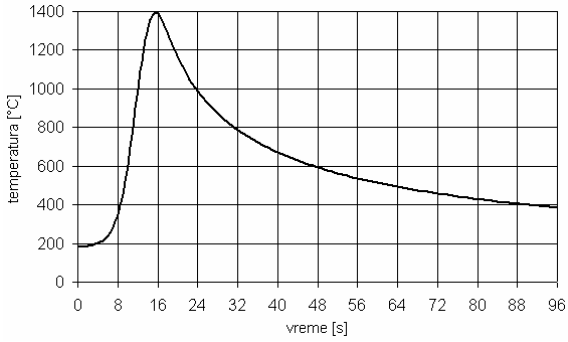

Figure 2 *Temperature cycle of HAZ hard faced layer (s= 7.4 mm ,q_l= 11058 J/cm, v_z= 0.208 cm/s, x= 4 mm, T_p= 180°C)*

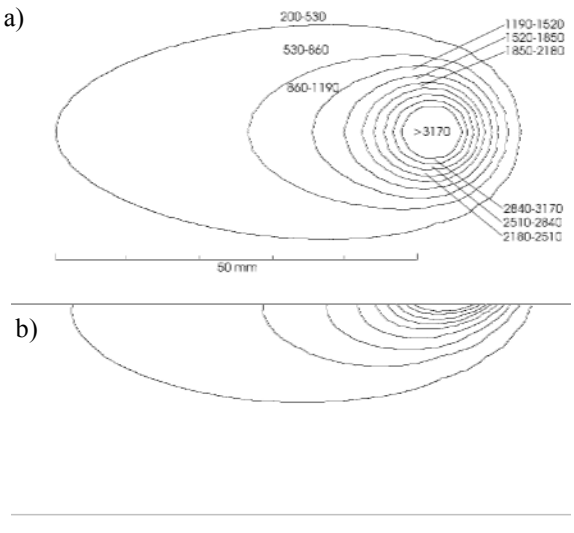

Figure 3 *Temperature field, a) from above, b) sideways, (s= 29 mm, q_l= 16500 J/cm, v_z= 0.258 cm/s, T_p= 204°C, at depth of 4 mm)*

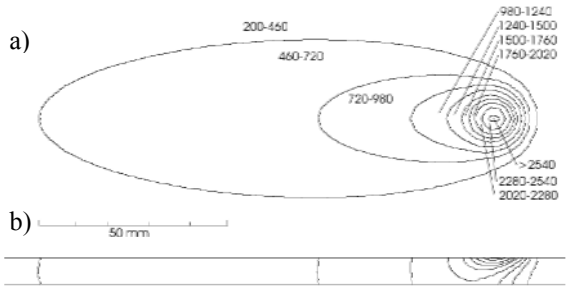

Figure 4 *Temperature field, a) from above, b) sideways, (s= 7.4 mm, q_l= 11058 J/cm, v_z= 0.208 cm/s, T_p= 180°C, at depth of 4 mm)*

Table 2 *Comparative values of cooling time - s=29 mm*

q_l, *J/cm*	Cooling time $t_{8/5}$, *s*				
	$(t_{8/5})^J$	$(t_{8/5})^{Sgr}$	$(t_{8/5})^{EXP}$	$(t_{8/5})^R$	$(t_{8/5})^{FEM}$
16500	10.43	14.89	12	13.5-14.5	11.5

Table 3 *Comparative values of cooling time - s=7.4 mm*

q_l, *J/cm*	Cooling time $t_{8/5}$, *s*				
	$(t_{8/5})^J$	$(t_{8/5})^{Sgr}$	$(t_{8/5})^{EXP}$	$(t_{8/5})^R$	$(t_{8/5})^{FEM}$
11058	20.1	84.9	27	42-50	31

4. ANALYSIS OF OBTAINED RESULTS

In the course of calculating cooling time $t_{8/5}$, the dilemmas as which formula, i.e. method to select imposes itself on us. In other words, so far it has not been identified which formula, i.e. method, gives the result closest to experimental cycle curve. Due to the analysis of only a few representative results (table 2 and 3), major (intolerable) differences are observed between cooling time calculated according to formula $t_{8/5}= f(s_{gr})$ and experimental results. The best conformity with experimental results is achieved by numerical method and formula of Japanese authors [5, 6, 8]. This conclusion refers to hard facing of the flat sheets, while we still haven't experimented with other forms of hard faced surfaces. By means of here selected empirical expression, i.e. proposed numerical method, time $t_{8/5}$, which is basis for selection of optimal parameters of hard facing regimes, and which can be used for fast estimation of output properties of hard faced layer, can be determined with required accuracy. Regarding numerical method, it represents a complex, but very reliable model for determining temperature fields and cycles, and can be used as a substitute for the expensive experiment. .

Cooling time ($t_{8/5}$) is mostly used for:

- *Determining of structure* in the most critical zone of HAZ hard faced layer, by inserting it into TTT-diagram [3, 5, 6, 7, 8, 9]. In the same way, main material can be selected among many materials according to e.g. required structure or maximal hardness, in dependence on condition of part operation.
- *Calculation of regime of* hard facing (q_l, T_p) which enables obtainment of hard faced layers of required properties regarding structure, hardness and toughness. In fact, time $t_{8/5}$ which matches the required structure (e.g.. martensite, martensite-bainite, bainite etc.) is adopted from KHZ-diagram, and then on the basis of formulas for $t_{8/5}$ [3, 5, 6, 7] operating power of hard facing is calculated as a single unidentified value.

5. CONCLUSION

When selecting the hard facing technology, attention must be paid to output properties of hard faced layer; for most steels, such properties, among others, are function of critical cooling rate and cooling time in temperature interval of minimal stability of austenite 800 do 500ºC-$t_{8/5}$. That is the reason why the reliable determining of cooling time represents the first condition which makes possible the influence on properties of hard faced layer. It was shown that information on the critical cooling rate and suitable transformation diagrams for selected steel provides fast, but somewhat rough estimation of output properties of hard faced layer.

It was proved that, in the process of calculating the cooling time, finite elements method achieves the best conformity with the experiment and among empirical formulas the expression of Japanese authors, for the case of hard facing of level and prismatic parts. By applying the specified information, cooling time in critical temperature interval can be determined with sufficient accuracy, without the complex and expensive experimental procedure which can only be carried out in research centres.

6. LITERATURE

1. **Kojić, M., Slavković, R., Živković, M., Grujović, N.:** *Metod konačnih elemenata I*, Univerzitet u Kragujevcu, Mašinski fakultet, 1998.
2. **Kojić, M., Slavković, R., Živković, M., Grujović, N.:** PAK-T Program for FE Heat Transfer Analysis – User manual, Kragujevac 2003.
3. **Jovanović, M., Adamović, D., Lazić, V.:** *Tehnologija zavarivanja-priručnik,* samostalno autorsko izdanje, Kragujevac, 1996., (prvo izdanje).
4. **Rikalin, N., N.:** *Rasčeti teplovih processov pri svarke,* M., Mašgiz, Moskva, 1951.
5. **Lazić V.:** *Optimizacija procesa navarivanja sa aspekta triboloških karakteristika navara i zaostalih napona*, doktorska disertacija, Kragujevac, 2001.
6. **M., Jovanović, M., Lazić, D., Adamović, N., Ratković:** *Procena tačnosti empirijskih formula za proračun vremena hlađenja ($t_{8/5}$) posle tvrdog navarivanja*, Zbornik radova, Četvrta međunarodna konferencija, Teška mašinogradnja, TM 2002, Kraljevo 2002., str. B.21-B.26.
7. **Brozda, J., Pilarczyk, J., Zeman, M.:** *Spawalnicze wykresy przemian austenity CTPc-S,* Wydawnictwo, "Slask", Katowice, 1983.
8. **Lazić, V., Josifović, D., Jovanović, M.:** *Validity of some formulae for calculation of cooling time during welding, Zavarivač*, 40(2), 1995., Beograd.
9. **Ito, Y., Bessyo, K.:** Weld crackability formula of high strenght steels*, J. Iron and Steel Inst., Jap*., No 13., 1972.
10. **Rakić Dragan:** Solving the fields problems of phisical dimensions using finite element method, *Final exam, Kragujevac 2004*

FLEXIBLE TOOL FOR POSITIONING AND CLAMPING THE ASSEMBLY THE CAR-BODY AND OTHER COMPLEX THREE DIMENSIONAL FORMS

B. Nedić, M. Kaplarević[1]

***Abstract**: Development of assembly accessories and its application for clamping in joint technologies (electricity resistant or forms of welding, brazing, pasting or with bolted connection) enabled multiple cutting down of time and expenses per product unit, due to accessory price, and also significant lowering of time needed for fulfilling conditions for manufacturing start. Due to applications of these tools, traditional tool construction and manufacture, which is connected with long production time and great expenses, are eliminated. Montage tools elements can be easily disconnected, after finishing production process. This way, the problem of storage or expenditure is also, successfully solved.*

***Key works**: flexible tools, positions, clamping, car-body, jiont technologies*

INTRODUCTION

Manufacturing of complex three-dimensional forms, whose most prominent representative is the car body, requires application of expensive tools of special design. When the matter in question is manufacturing in large series application of such tools is worthwhile. However, in manufacturing the small series, application of special, complex tools, increases the production price up to the extent that their application is almost excluded.

Basic requirements that a car body tool should fulfill, in order to manufacture high quality assembly, are the following:

- precise positioning and clamping of the assembly components,
- free access of welding elements or other devices, and
- easy assembling of elements and removing of the welded assembly.

These enumerated requirements ought to be satisfied regardless of the manufacturing series, which assumes application of tools for whose construction and manufacturing adequate money resources should be invested.

Problems that appear in cases like these in small series manufacturing of assembles are:

- high share of the tool costs in the product price,
- tool construction costs also have a significant place in assembly manufacturing development and
- long period of time since the construction till the tool manufacturing, namely till the start of production, what can affect the competitiveness of the manufacturer.

DEVELOPMENT OF THE FLEXIBLE SYSTEM

In contemporary manufacturing practice, car body tools are designed for manufacturing of a single assembly, and the automatization degree depends on the magnitude of the manufacturing series of the relevant assembly. Since the topic here is a small series production and manufacturing of prototypes, the tool must correspond to such production, what assumes that positioning of elements and their clamping are manual.

Car body assemblies have a complex form that is defined by variables in the three-dimensional orthogonal reference frame. The problem of manufacturing such assemblies within the given tolerances is basically a problem of positioning and clamping of the assembly components, in such a manner that necessary welding are possible to perform, or some other form of joining, and a problem of obtaining the assembly within the prescribed tolerances. The same applies for assemblies of the complex three-dimensional forms in other branches of the metal working industry.

Minimal configuration of the car body tool consists of the work bench, referent and clamping group. The work bench size, number and optimal arrangement of the referent and clamping groups, are functions of size and complexity of the assembly, and independent of the manufacturing series of the produced assemblies.

The fundamental idea which led to development of the **flexible system** is the need for realization, on a single bench, of large number (practically unlimited) of combinations of positioning, supports and clamping, through realization of freedom of adjustments in all

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directions of the perpendicular coordinate system **XYZ**, together with rotation of elements.

The aim of the **flexible system** development was to solve the problem of economic manufacturing of the car body assemblies, as well as other assemblies of complex three-dimensional forms which are produced in small series or in individual production, and in manufacturing of prototypes in all the areas of production.

Design was realized through system of elements whose construction solutions enable complete covering of the area above the work bench, combining their mutual mating and possibility of adjustments of relative positions of elements and possibility of adjustment of the completed assembly on the work bench by help of the cut in "T" grooves.

Flexible tool for positioning and clamping the assembly the car-body and complex three dimensional forms consists of the working bench with "T" channels, basic support assemblies, basic support plates, support and plate holder, elements of the device for fast fixing. It has a constructively solution so that the basic elements of the system through their shape, size, position and relation of the holes for screw connections provide total covering of the space above the working bench surface, till the range which depends of the selected sizes of the basic welded assemblies and basic support plates.

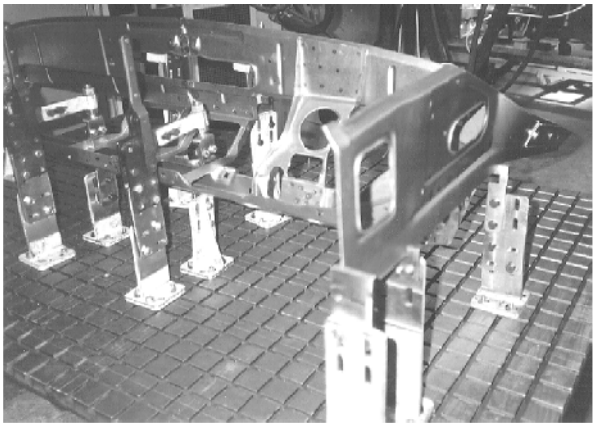

Fig. 1.

Fundamental elements of the system, manufactured by the criteria imposed by theoretical principles of covering the space, enable realization of the complete covering of the work bench space and also along the height, which is adopted for height of the welded assemblies and basic supporting plates. This actually means that it will be possible to realize practically unlimited number of combinations of the referent and clamping groups, within range that we can set freely by the work bench dimensions and basic elements of the flexible system.
In the figures are presented examples of practical application of the flexible apparatus in manufacturing of car body assemblies of a truck (fig. 1 to fig. 8.) and other clamping (fig. 9 and 10).

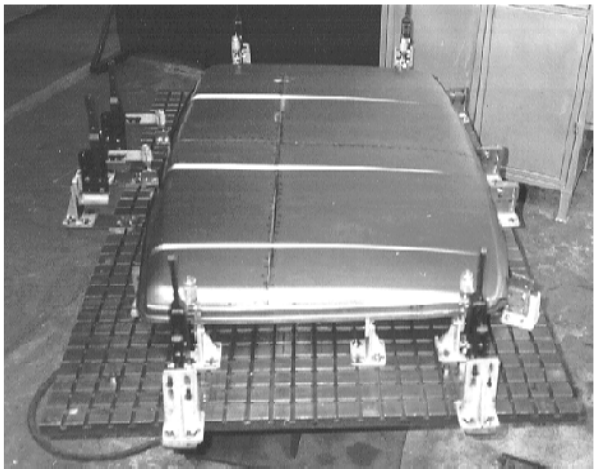

Fig. 2.

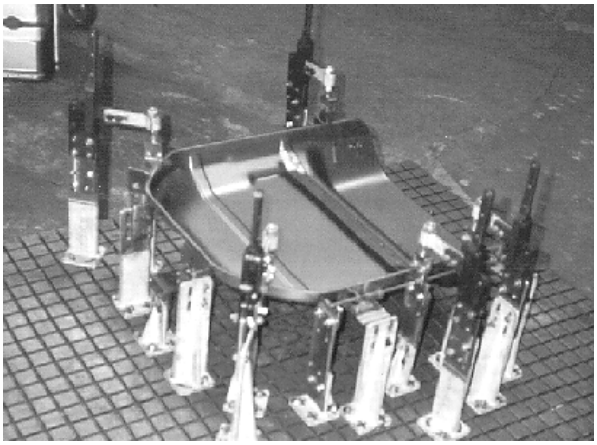

Fig. 3.

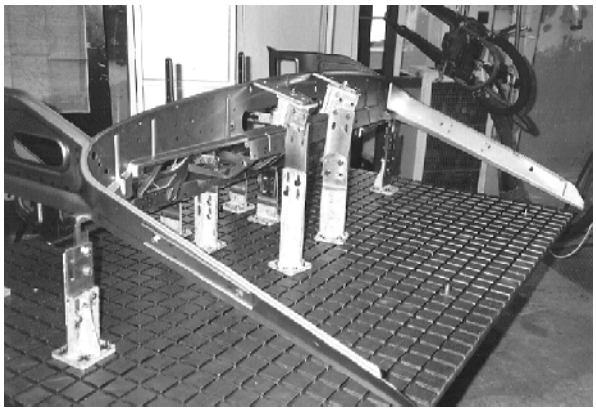

Fig. 4.

Flexible tool enables complete fulfillment of requirements that a car body tool should satisfy, through application of standard system elements and eventual construction of specific elements (supports, clampers, etc.) that would later be used for forming the tool configuration for the relevant assembly.

Fig. 5.

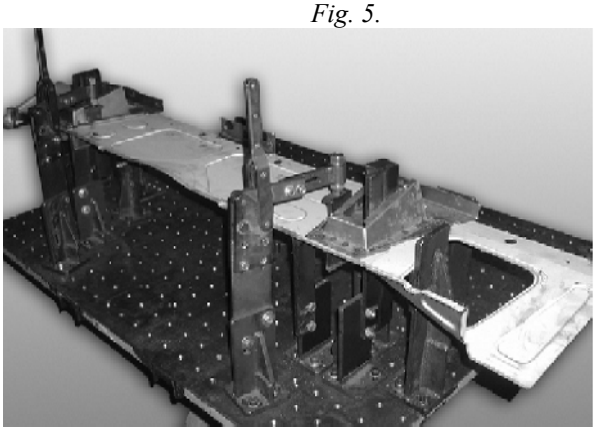

Fig. 6.

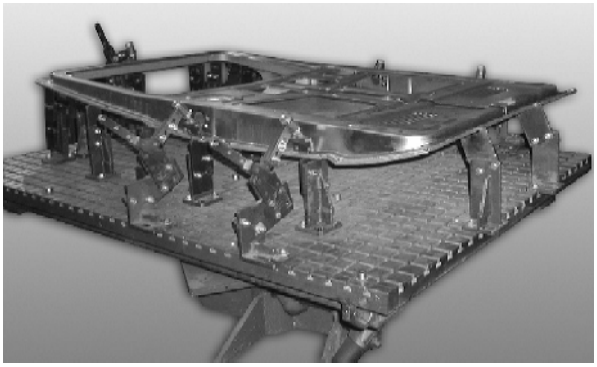

Fig. 7.

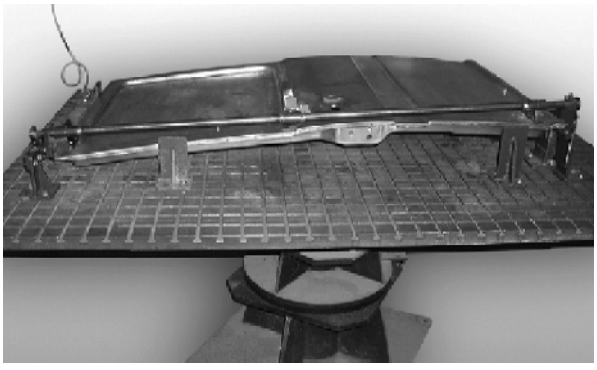

Fig. 8.

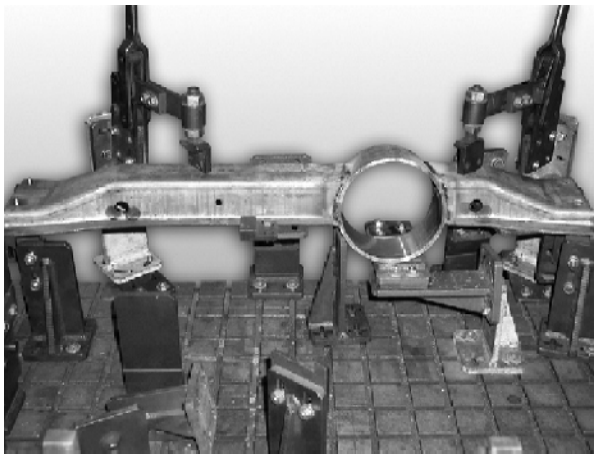

Fig. 9.

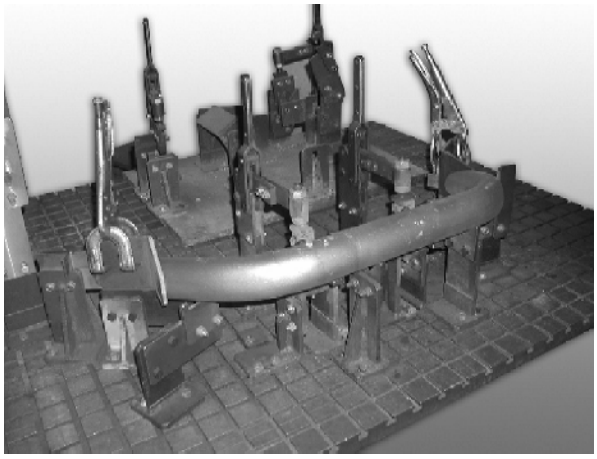

Fig. 10.

Tool construction for forming the relevant assemblies on the **flexible tool** represent the optimal combination of standard elements to obtain desired clamping and referent groups. As it was already mentioned the specific elements are drawn whose functions can not be obtained by application of the standard system elements.

Forming of the defined tool construction for the particular assembly is done according to verified sample of the relevant assembly, by measuring in the work bench coordinate system or combined. After completed manufacturing the groups are taken off and the configuration of tools for manufacturing the new assembly can start.

Besides manufacturing the car assemblies in regular production, the **flexible tool** can successfully be used in prototype production of the mentioned assemblies, then in mounting and welding of different other assemblies of complex three dimensional forms.
The most important advantages of the **flexible tool** are the following:

- multiple decrease of products per product unit from the aspect of tool price,
- multiple shortening of time needed for creation

of production conditions,
- multiple shortening of time needed for tool construction, and
- complete elimination of time delay for tool manufacturing.

In manufacturing of prototypes and samples enabled is:

- measuring in coordinate system of the work bench and
- easier positioning and fixing of the assembly components.

CONCLUSION

Starting from characteristics of the production process in "Zastava-Trucks", O.U. "Car body", for manufacturing the large number of vehicles versions in small series, where appears the significant number of assemblies of very complex forms, for which it is necessary to have tools to achieve the desired quality, and from the many year work on designing the complex tools for manufacturing the car body assemblies, we came up with development and realization of the prototype flexible system for clamping the parts during the electric resistance welding (joining) of assembly elements.

The realized system, based on a set of corresponding elements for positioning and clamping, and the basic plate for their placing and connecting, enabled obtaining of the universal tool what caused multiple decrease of costs per product unit form the aspect of the tool price, multiple shortening of time needed for construction and manufacturing of tools, multiple shortening of time for initiation of production. By application of the flexible system is also realized many-sided help in technological analysis of manufacturing the assemblies of the complex three-dimensional forms for serial production.

REFERENCES:

1. *Kršljak, B.*, "Manufacturing Techniques", Scientific Book, Belgrade, 1992.
2. *Vukelja, D.*, "Construction and Calculation of Accessory Devices", Faculty of Mechanical Engineering, Kragujevac, 1978.
3. *Kaplarević, M.*, Patent 49007, Belgrade, 2003.
4. Nedic, B., Kaplarevic, M., Jecmenica, R., Development of assembly accessories for clamping in joint technologies, Jupiter conference, Belgrade, 2000.

МОДЕЛИРОВАНИЕ ПРОЦЕСОВ ПРИ ЗАЛИВКЕ ЛИТЕЙЫХ ФОРМ ЖИДКИМ МЕТАЛЛОМ

К.Л. Петров - ТУ-София, П. Добрев - ТУ - София, Р. Петков - ХТМУ - София[1]

Моделирование процессов осуществляется при помощи модели литниковой системы, выработанной из прозрачной пластмассы. При проектировании модели применена теория подобия. В целях моделирования шлаки исползуются пенополистирольные жемчуги, плакированные парафином.

Моделирование, литниковая система,

Модель находит применение в учебной и научно-исследовательской деятельности в лаборатории литья при кафедре МТМ.

В лаборатории литья при ТУ-София в учебных целях разработана и применяется модель литниковой системы. При выработке модели соблюдены следующие требования и последовательность разчёта:

1. Требования

♦ Модель литниковой системы должна бить подобна оргиналу в гидродинамическом отношении. Согласно теории подобия для этой цели необходимо и достаточно, чтобы между ними существовало геометрическое подобие и подобное распределение скоростей рубежных сечений.

Это требование может бить записано математически следующим образом, при условии, что движение является стационарным, а флюид – несжимаемым:

$$L = idem \qquad (1);$$

$$Re = \frac{w.l}{v} = idem \qquad (2);$$

От (2) следва:

$$\frac{w.l}{v} = \frac{w'.l'}{v'} \text{ или } \frac{w}{w'} = \frac{\frac{v}{v'}}{\frac{l}{l'}}$$

$$m.e.\ C_w = \frac{C_v}{C_l}, \qquad (3)$$

где C_w , C_l, C_v, являются соответственно константами подобия скорости, линейых размеров и кинематической вязкости;

Re – является критерием Рейнольдса;

Знаком (′) отмечены величины, касающиеся модели.

Равенство (3) означает, что между константами подобия скорости, вязкости и геометрических размеров существует жёсткая зависимость. Это означает на самом деле, что произвольно можно выбирать лишь стойности только двух из констант. Чаще всего этами константами могут быть константы подобия размеров и вязкости, так как хорошо было бы заранее определить масштаб, в котором будет построена модель и моделирующая жидкость.

Для моделирования выбрана закрытая литниковая система с вертикальным дроселем для чугунных отливок массой с 6÷12 kg.

2. Последовательность расчёта

♦ определение сечения “узкого места” т.е. минимального сечения F_n или же сумма сечений питателей ΣF_n по формуле Озана:

$$F_п = \frac{G}{\mu\beta z\sqrt{H_p}}$$

G - масса отливки, *[kg]* ;

μ - коэффициент гидравлических потерь в каналах литниковой системы и отливки;

β - коэффициент, зависящий от вида металла;

z - время заливки *[sec];*

H_p - металлостатическое давление; *[cm]*.

♦ определение сечения остальных элементов системы: *Fшл* – сечения шлакоуловителя, *Fл* - сечения литника и *Fотл*.- сечения отливки, применяя следующую практически установленную зависимость:

$F_п:F_{шл}:F_л = 1:1,1:1,15$ для небольших и средних чугунных отливок;

Получнные после проведённых расчётов результаты, следующие:

$F_n = 3,92\ cm^2$;

$F_{шл} = 1,1.\ F_{пит} = 1,1.3,92 \approx 4,3\ cm^2$;

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$$F_л = 1,15.F_{пит} = 1,15.3,92 \approx 4,5\ cm^2$$

Модель построена в масштабе 1:1, т. е. значение константы подобия размеров - один. В качестве моделирующей жидкости используется вода кинематическая вязкость которой (0.01 cm^2/s) приблизительно равна кинематической вязкости жидкого металла с нормальным перегревом. Это означает, что значение константы подобия вязкости будет один. Значения обеих констант однозначно определяют значение третьей константы подобия скорости – в данном случае она тоже один.

На основе сделанного анализа проведёных расчётов выработана модель из органического стекла (полиметиле метеллкрилата) – рис.1.

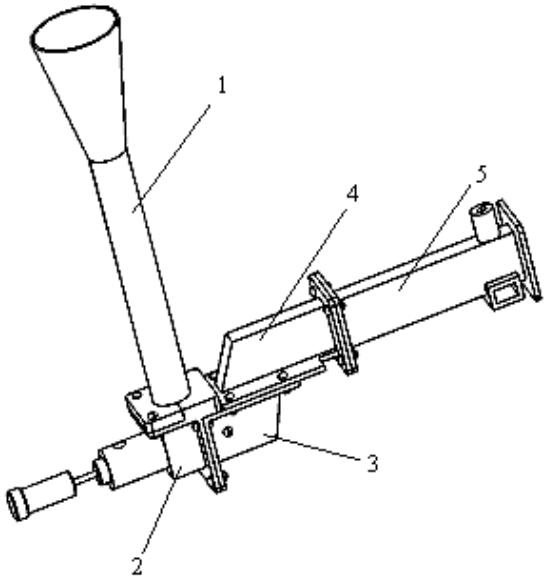

Рис. 1

Модуль 1 – литник, Модуль 2 – зумпф, Модуль 3 - вертикальный дросель, Модуль 4 – шлакоуловитель, Модуль 5 – шлакоуловитель с питателем;

Основной целью выработанной модели является учебная – для пояснения студентуми процессов, протекающих литниковой системе, которы нельзя наблюдамиь прямым образом.

Моделирование даёт возможность получить и количественные рзультаты, выражающие степень шлакозадержки в процентах при различных соотношениях сечений элементов литниковой

системы и дебита. Это даёт возможность проведения ряда экспериментов состороны студентов, например:

Посредством шлюзного устройства, выработанного в зумпфе (позиция 2 на рис.1), студенты вводят в поток определённое число моделирующих шлак частиц (пенополистирольных сфер диаметром 0.5÷1mm) и отчитывают в процентах задержанные шлакоуловителем при различных сечениях и дебите - графика 1 .

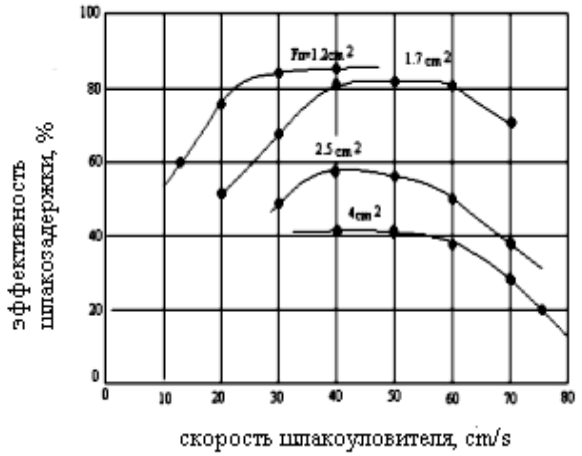

График 1

Таким образом они понимают значение оптимального комбинирования указаных вычие факторов плотных и прочных отливок.

Конструкция модели является модульной, причём даёт возможность дополнительного оформления её отделных элементов с помощью подвижных пластин или же пластичной масси (пластилина). Студенты активно моделируют и наблюдают картину заполнения литниковой системы с наличием возможности внести коррекции в систему, как таковую, например с целю:

- найти оптимальное соотношение между площадью сечения элементов литниковой системы;
- определить давление в различных сечения;
- отвести металл через отдельные питатели в необходимом количестве и последовательности;
- определить затрату метала и коэффициент цопротивления;
- создат условия спокойного прохождения металла в литниковой системе;

заключение можно сказать, что применение физической модели литниковой системы в учебной деятельности является хорошим способом привлечь интерес студентов, кроме того их активное участие в моделировании некоторих из процессов ведёт к лучшему осваиванию учебного материала.

1. Гуляев Б. Б., “Теория литейных процессов”, Ленинград, Машиностроение, 1976.
2. Р. Петков, С. Атанасов, “Върху някои проблеми в шлакозадържането в леяковатра система” – Национална-научно техническа конференция “Леярното производство – съвременни технологии, пазари, проблеми” Ловеч–27-28 октомври 1994 г.

AUSTEMPERING OF ALLOY SPHEROIDAL GRAPHITE CAST IRONS

J. Kaleicheva, N. Kemilev, V. Mishev[1]

Abstract:

The paper presents the results of the study on some peculiarities of structure formation in the bainite range of alloy spheroidal graphite cast irons. The austempering is done at a temperature of 420 oC from 5 to 300 min. An optical metallographic analysis, an electron-microscope analysis, a x-ray phase analysis and testing of Vickers hardness have been done. The influence of the chemical composition and the austempering regime on the phase composition, microstructure and hardness of alloy spheroidal graphite cast irons has been examined.

Key words: *alloy spheroidal graphite cast irons, austempering, bainite transformation, upper bainie, α-phase, retained austenite, martensite, carbides.*

INTRODUCTION

The spheroidal graphite cast irons are an efficient material of construction combining good technological features with high physical-and-mechanical properties. Their mechanical properties can be improved by alloying with different elements in certain concentrations and proportions and by different heat treatments. A considerable improving of the strength and plastic properties can be achieved by austempering, with which the bainitic spheroidal graphite cast irons with a tensile strength of $R_m > 1000$ MPa and relative extension of A > 10 % are obtained. The spheroidal graphite cast irons with a bainitic metal basis have high wear-resistance with friction by sliding and rolling and with abrasive wear-out. Depending on the austempering regime, cast irons with a structure of lower bainite or upper bainite are obtained. The lower bainite structure (220-280^{o}C) is characterized with high strength and wear-resistance and the structure of upper bainite (350-450^{o}C) increases plasticity and toughness. These materials are used successfully for manufacturing of gears, cast crankshafts and other parts of transport equipment [1, 2].

The aim of the examination carried out is to study the structure formation in the bainite range of non-alloy and alloy with Mo and Cu spheroidal graphite cast irons.

METHODOLOGY OF INVESTIGATION

The paper presents the results of the study on the bainite transformation in three groups of spheroidal graphite cast irons with different chemical composition: non-alloy, alloy with 0,22 % Mo and alloy with 0,22 % Mo + 0,50 % Cu (Table 1).

Table 1

Group of irons	Chemical composition, %						
	C	Si	Mn	P	Ni	Mo	Cu
1	3,43	2,60	0,30	0,05	0,01	0,01	0,02
2	3,59	2,58	0,31	0,05	0,01	0,22	0,02
3	3,53	2,69	0,30	0,05	0,01	0,22	0,50

All samples examined after casting have been subjected to normalizing at 900 ^{o}C, 2 h. The austempering is done after heating at 900 ^{o}C, 1h, in a salty bath at a temperature of 420 ^{o}C from 5 to 300 min (Fig.1).

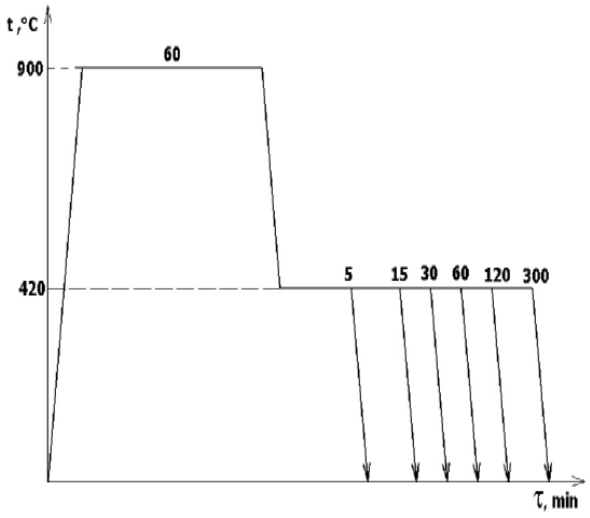

Fig. 1. Diagram of austempering regimes.

The microstructure has been examined by an optical metallographic analysis and an electron-microscope analysis. The quantity of the retained austenite has been determined by a X-ray phase analysis. The test of Vickers hardness has been done with a load of 500 g.

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EXPERIMENTAL RESULTS AND ANALYSIS

In the most common case with the bainitic transformation the structure formed consists of a martensite α-phase supersaturated with carbon (bainitic ferrite), retained austenite with a carbon concentration different from the average one, carbides formed both directly from the austenite and with the decay of the α-phase as a result of self-tempering. Under certain conditions, some products of pearlitic and martensitic transformation can also exist together with the products of bailitic transformation. [3].

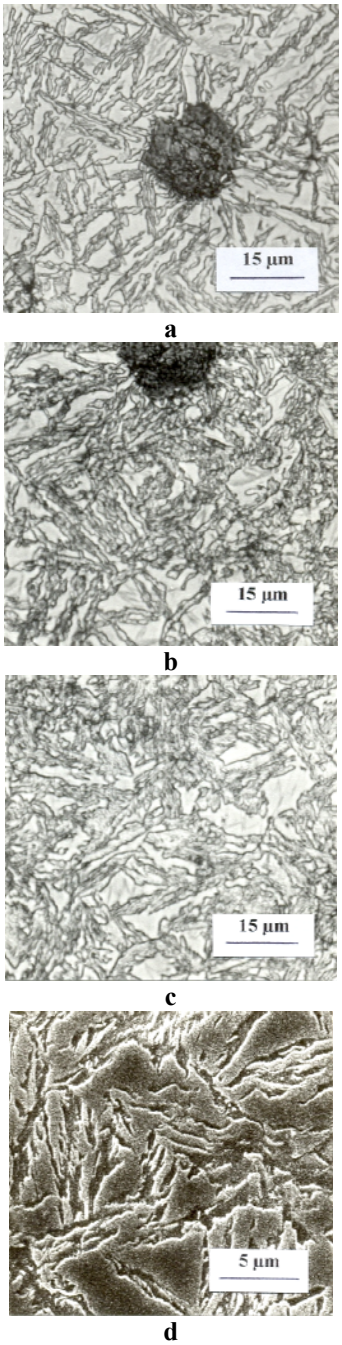


Fig. 2. Microstructure of non-alloy spheroidal graphite cast irons after austempering at 420 °C, 15 min (a), 1 h (b), 2 h (c) and 5 h (d).

As a result of the austenite austempering in the cast irons examined at a temperature of 420°C an upper bainitic structure is obtained. At the beginning of transformation the upper bainitic structure in the non-alloy spheroidal graphite cast irons consists of oriented α-phase plates, retained austenite and martensite formed from the untransformed austenite with cooling to the room temperature. Packets of α-phase plates and untransformed austenite following each other are formed (Fig. 2 a, d). With the development of transformation the α-phase plates grow laterally and lose their orientation (Fig. 2 b, c). During the first 15 minutes the retained austenite A increases and reaches 45 %, then decreases sharply and after the isothermal transformation from 60 до 300 min it changes inconsiderably, from 15 to 12,5 % (Fig. 3).

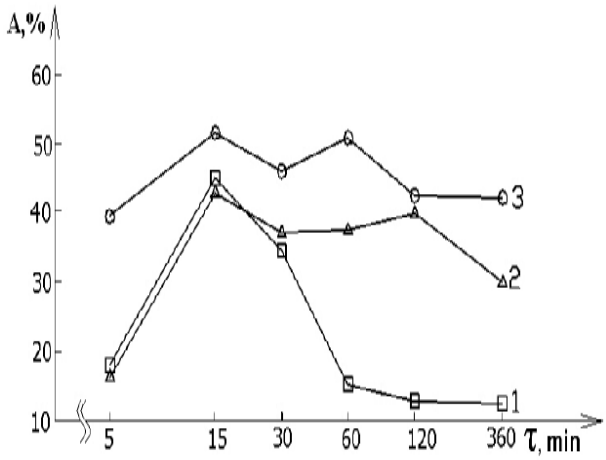


Fig. 3. Change of the quantity of retained austenite A according to the time of isothermal transformation at 420 °C in non-alloy (1), alloy with 0,22 % Mo (2) and alloy with 0,22 % Mo + 0,50 % Cu (3) spheroidal graphite cast irons.

The cast irons examined contain silicon of 2,6 – 2,7 % (Table 1). It is known that the bainitic transformation in the iron-carbon alloys with silicon results in considerouble enriching of the non-transformed austenite with carbon even at an initial carbon concentration of about 1 %. Silicon makes the direct emission of carbides from the austenite difficult due to the decrease of the thermodynamic activity of iron. However, on a certain stage of the bainitic transformation development at temperatures of 400-450 °C the carbide phase in the iron-and-carbon alloys containing silicon is either directly separated from the austenite enriched with carbon or this austenite decades to a ferrite-and-carbide mixture [3]. In the non-alloy cast iron examined, with the transformation development after 15 min a ferrite-and-carbide mixture is probably formed (Fig. 2 b, c), which is the reason for the sharp decrease of the quantity of retained austenite A (Fig. 3). The hardness is changed from 305 to 335 $HV_{0,5}$, which is the biggest one after the isothermal transformation at 420 °C, 30 min (Fig. 4).

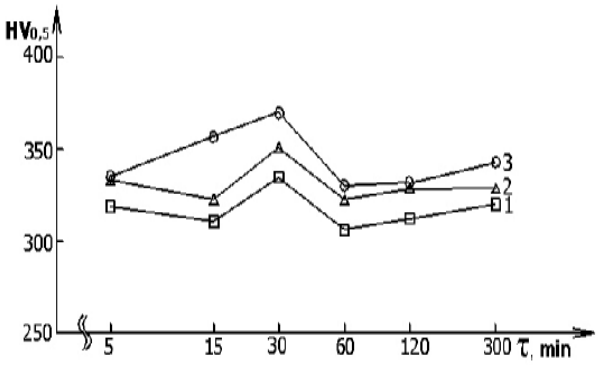
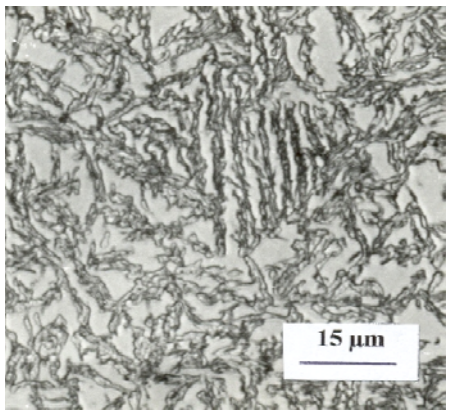
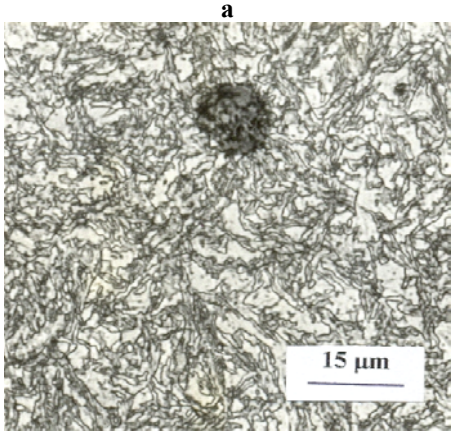


Fig. 4. Change of hardness $HV_{0,5}$ according to the time of isothermal transformation at 420 °C in non-alloy (1), alloy with 0,22 % Mo (2) and alloy with 0,22 % Mo + 0,50 % Cu (3) spheroidal graphite cast irons.



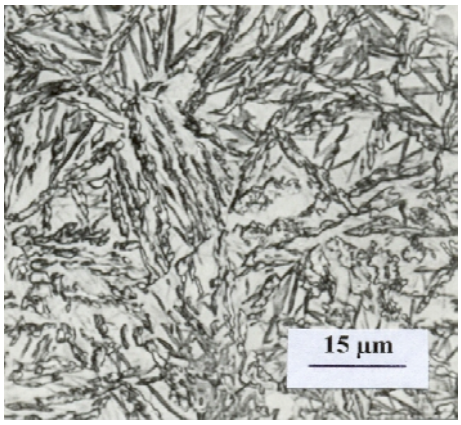
a



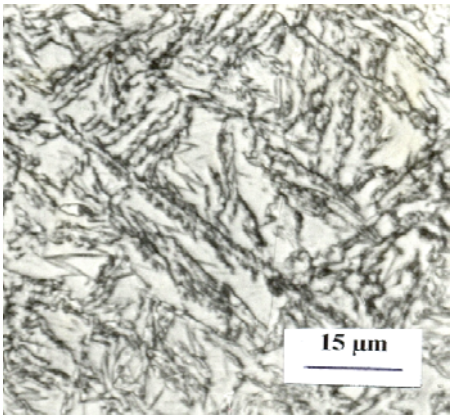
b

Fig.5. Microstructure of alloy spheroidal graphite cast irons with 0,22 % Mo after austempering at 420 °C, 1 h (a) и 5 h (b).

The alloying with 0,22 % Mo influences on the kinematics of the bailitic transformation at 420 °C. The bailitic structure is more disperse and the α-phase plates, unlike those in non-alloy cast iron, keep their orientation even after 60 min of isothermal transformation (Fig. 5a). The quantity of the retained austenite A increases to 43 % during the first 15 min, then it stabilizes and remains unchanged up to 120 min at 420 °C (Fig. 3). After 300 minutes of isothermal retaining, with which the retained austenite A decreases to 30%, it is possible to form ferrite-carbide mixture of the austenite enriched with carbon. Hardness changes from 320 to 350 $HV_{0,5}$ and is higher than those in the non-alloy cast iron (Fig.4).



a



b

Fig. 6. Microstructure of alloy spheroidal graphite cast irons with 0,22 % Mo + 0,50 % Cu after austempering at 420 °C, 1 h (a) и 5 h (b).

The influence of Mo (beginning with 0,2 %) appears in improving the cast iron strength properties. Molybdenum makes the metal basis stronger dissolving in the hard solution and forming disperse carbides stabilizing the grain boundaries. [1]. The complex alloying with Mo and Cu allows obtaining of cast irons with a bainitic structure possessing high strength and plasticity at the same time. The alloying with Cu improves the strength properties, neutralizes the carbide-forming activity of Mo and increases the cast iron corrosion resistance [1,2].

After austempering at 420 °C the hardness of the cast irons alloyed with 0,22 % Mo + 0,50 % Cu changes from 330 to 370 $HV_{0,5}$ and is greater than that of the non-alloy or alloy cast iron with 0,22 % Mo (Fig. 4). The simultaneous alloying with 0,22 % Mo and 0,50 % Cu changes the morphology of the upper bainitic structure (Fig. 6). With the development of the transformation, the α-phase preserves the characteristic martensite orientation of the plate without expressed

lateral increasing (Fig. 6 b). The quantity of the retained austenite A increases during the first 15 minutes (51,5 %), after which it remains a constant up to 60 min and then, after 300 minutes, it decreases to 42 % at 420 ^{o}C (Fig. 3). The quantity of the retained austenite A in the cast irons alloyed simultaneously with Mo and Cu is bigger in comparison with that in the non-alloy cast irons and cast irons alloyed with Mo for all times of isothermal retaining. That is explained with the fact that the additional alloying with 0,5 % Cu decreases point M_s with cooling the untransformed austenite from 420 ^{o}C to the room temperature influencing the kinetics and degree of austenite transformation in the bainite range.

CONCLUSION

The microstructure of the austempering spheroidal graphite cast irons with different chemical compositions has been studied at 420 ^{o} C from 5 to 300 minutes. The alloying with 0,22 % Mo and the complex alloying with 0,22 % Mo and 0,5 % Cu influence on the kinematics of the bailitic transformation, the disperse character of structure ingredient, on the degree of the austenite decay and on the morphology of the bainitic structure. The alloying with 0,22 % Mo and with 0,22 % Mo + 0,50 % Cu increases the hardness and the quantity of the retained austenite in the structure of the examined austempering cast irons.

REFERENCES

1. Shebatinov M. P., Yu. E. Abramenko, N. I. Beh. High-strength Cast Iron in Automobile Industry. Moscow, Mashinostroenie, 1988, 213 p. (In Russian)
2. Dorasil E. High-strenght Bainitic Nodular Cast Iron. Prague, Academia, 1985, 170 p. (In Czech)
3. Kurdyumov G. V., L. M. Utevskiy, R. I. Entin. Transformations in Iron and Steel. Moscow, Nauka, 1977, 237 p. (In Russian)
4. Rashev G., J. Kaleicheva, N. Martoviskaia. Peculiarities of Structure Formation in Isotermal Quenched High-strength Cast Iron. Scintific Works, Metal Science and Technology of Metals, Rousse, 1994, V. XXXV, S. 2, pp. 203-209. (In Bulgarian)

APPLIANCE OF TRIZ METHOD IN CHOICE OF TECHNOLOGY FOR SOLVING PROBLEM OF WOODEN WASTE

Dragan Milčić, Miroslav Mijajlović, Boban Anđelković[1]

Abstract:

One of the great problems of wood industry is problem of manufacturing and exploitation of wooden waste. In order of more economic dealing,, the ways of more efficient exploitation of all resources are searched to achieve greater material benefits From ecological point of view, that is the problem of all public community .Problems are: how to more efficiently resolve of wooden waste from wood exploiting companies, how to make a good hand of it in regard to receive useful product from it which can be soled at the market. Possible solution is making wood pellets. This paper, shows appliance of TRIZ method in decision of technology for solving problem of wooden waste and selection of wood pelleting system

Key words*: wooden waste, wood pellets, TRIZ method*

1. INTRODUCTION

In, not so distant past, problem of wood waste was solved in of these ways:
- leaving wooden waste on, mostly, illegal dumps, to putrefy or burn,
- translating wooden waste in so called wooden briquettes in order of easy manipulating and exploitation of wooden waste,
- burning wooden waste in specialized systems with very small efficiency factor, with great exploitation costs.

Latest researches say that great number of people in Western and Northern Europe and USA, in accordance with their tradition, proceed to heating on wood, using wood waste, transformed into, so called, wood pellets. In next passages, more words will be about how, by seeing and analyzing problem, using TRIZ method, the most efficient technology for solving wood waste was found

Definition of TRIZ, explained at the easiest way, says, that this is a theoretical discipline which gives to researcher (mostly: engineer, scientist, any human being), assembled knowledge and skills in some theoretical area, with manual, in tribute of systematical searching of solutions for some problems. "Father" of TRIZ method, Genrich Soulovich Altschuller (1926.-1998.), unconventional and genial scientist and minder from Russia (former SSSR).

Analyzing more problems occurred in technical branch, Altschuller concluded:
aim of development is ideal;
- problem, which is run at, is spanned only if the existing contradiction is solved.;
- only innovations make;
- one innovation process can be partitioned step by step.

2. SYSTEMATICAL SEARCHING FOR SOLUTION FOR WOOD WASTE PROBLEM USING TRIZ METHOD

Due to systematical finding most quality solution, it is necessary to define dominant constructive indexes of system for solving wood waste problem and grade them. Index grading system: good-1.0, satisfinig-0.5, unsatisfing-0.0. Grading (determining partial indexes) puts thru team of experts from every of named areas, whose partial indexes we are searching for.

Totally index is estimated as an arithmetical middle of partial indexes.

Due to data, shown in Table1, chronology of development of idea can be seen, also. Totally index grows analogically with improvement of solutions. Due to Table 1, optimal solution for wood waste problem is pelleting (highest value of index).

Table 1.

Problem solving method	Leaving on dumps	Burning in furnaces	Briquetteing	Pelleting
Economical indexes	0.0	0.5	1.0	1.0
Technical indexes	0.0	0.5	0.5	1.0
Ecological indexes	0.0	0.0	0.5	0.5
Totally index:	**0.0**	**0.33**	**0.67**	**0.83**

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Based to former analyses of technologies can be concluded that pelleting technology is advanced in relation to other technologies.

Advantages of peletting technology in relation to other technologies are:

1. Shape and dimensions of final product are suitable for automation process of firing, so it is possible to create central heating system with automation regulation.
2. Easier transport and possibility of storing because of dimensions of final product (wood pellets). It is possible to ecologically pack products (3 kg bags).
3. Greater machine capacity (ten times greater then briquetteing machine).
4. Briquetteing machine's work is cyclic with empty returning action, while pelleting machine's work is continual. Less energy decrement and use of working time is for the same quantity of machined wood waste.
5. New technology.
6. Products reproduced by this technology are standard (DIN 51731), so there is possibility to export them.

Eventual disadvantage of pelleting technology could be slightly greater cost of technology then briquetteing technology.
Dominant constructive indexes are defined thru lists of requests (R) and wishes (W). (Tables 2 to 6)
After defining of lists of requests and wishes, it is necessary to do modeling of partial functions of system for pelleting, using Altschuller's matrixes. Easiest way for modeling of functions is by scheme shown on Figure1.

Table 2. Basic systems function

No	Systems functionality	Class (R/W)	Origin
1.	Wood waste pelleting	R	buyer

Table 3. Functional requests/wishes.

No	Systems functionality	Class (R/W)	Origin
1.	Pelleting system's capacity 1÷1,5 t per h	R	buyer
2.	Pellet's diameter 6 mm	R	buyer
3.	Pellet's length 15÷30 mm	R	buyer
4.	Homogeny structure of pellets	R	buyer
5.	Pellet's density 600 kg/m3	R	buyer

Table 4. Economical requests/wishes.

No	Systems functionality	Class (R/W)	Origin
1.	Minimal price for system	R	developer
2.	Minimal number of working needed for proper functioning of system for pelleting	R	buyer
3.	Maximal system's capacity	R	buyer
4.	Working life of system ≥15000 h	R	buyer
5.	Easy maintenance of system	R	buyer

Table 5. Technological requests/wishes.

No	Systems functionality	Class (R/W)	Origin
1.	Simple and easy construction	R	developer
2.	Easy installing and uninstalling	R	developer
3.	Modula principle of building	R	developer
4.	Appliance of standard parts	R	buyer

Table 6. Aesthetically, ecological and ergonomic requests/wishes.

No	Systems functionality	Class (R/W)	Origin
1.	Settled and silent work	R	buyer
2.	Reliability in work	R	buyer
3.	Easy handling with system	R	buyer
4.	Harmless for environment	R	buyer
5.	Modern design of system	R	buyer

TRIZ method uses two types of functions: useful and harmful.
Models of functions are building by mutual connecting of various useful (UF) and harmful (HF) functions

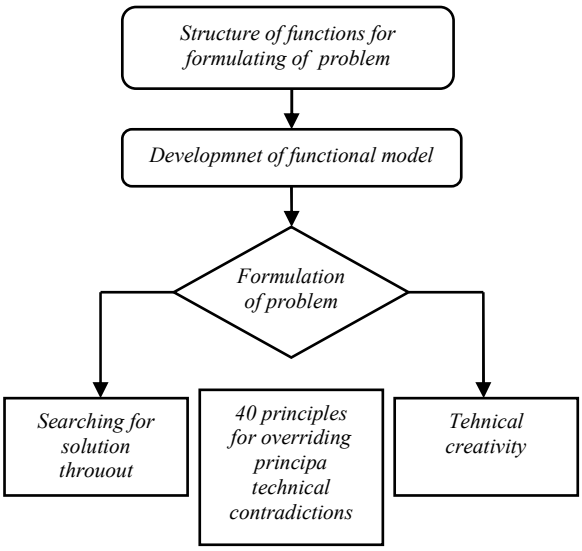

Figure 1.

Building of model is achieving by systematic questionnaire of considered technical system. Technique is like it appears:
1. Ask yourself "What is familiar useful function of system?" and write it down;
2. Ask yourself "What is familiar harmful function of system?" and write it;
3. Ask 4 questions about familiar useful function and supplement model of functions with additional functions and relationships;
4. Ask 4 questions about familiar harmful function and supplement model of functions with additional functions and their relationships;
5. Ask for new functions according to 3 and 4 and supplement model of functions by additional functions and their relationships;

6. Stop building model of functions when all important useful and harmful functions of system are shown.
Building of model of functions for pelleting system looks like this:
l. What is familiar useful function of system for pelleting wooden waste? Pelleting of wooden waste
1.1. Is for filling out pelleting function necessary other useful function?
1.1.1. Importing of raw wooden waste
1.1.2. Triturating of wooden waste...
1.1.7. Disposal and synchronization of full system's work
1.2. Are these harmful functions cosign any other harmful function?
1.2.1. Pollution of environment because of exhausting gases
1.2.2. Pollution of working area. Dust creating.
1.2.3. Pollution of working area. Exhaust waterish air out of building.
1.2.4. Heating of wooden waste during pelleting process and existing of possibility of firing after process of pressing.
1.2.5. Complexness of system...
2. What is familiar harmful function of pelleting system? There is no harmful function.
After finished building of function model, it is necessary to decompose function.
To create pellets, it is necessary to pass all of these phases: 1) triturating of wooden waste, 2) drying, 3) pressing and 4) cooling.

Table 7.

1.	Mass/weight of movable objects	20.	Unmovable object's consummation of energy
2.	Mass/weight of unmovable objects	21.	Power, capacity
3.	Movable object's length	22.	Energy loss
4.	Unmovable object's length	23.	Material loss
5.	Moveable object's area	24.	Information loss
6.	Unmovable object's area	25.	Time loss
7.	Moveable object's volume	26.	Quantity of material
8.	Unmovable object's volume	27.	Reliability
9.	Velocity	28.	Precision of measurements
…	…	…	…
17.	Temperature	36.	Structure complexity
18.	Dimensions ratio	37.	Controlling and measurement complexity
19.	Moveable object's consummation of energy	38.	Automation level
-	-	39.	Productivity

At that, contradiction, basic problem in TRIZ building model method, Alschuller defined as basic ratio mutually exclusive statuses, which are directed to only one function, component or all integrity of system Altschuller defined 39 standard technical attributes of contradictions, shown in Table7. Detailed analysis, trails to great number of contradictions, but, in this paper, only two of them will be considered: Increasing object's connections stability (Table8.) and Increasing of mass upwards decreasing volume (Table9).
From pointed contradictories attendant that jointly principle of solving problem is 35- Universality, capability of accommodation, i.e. this is about transition between modes during manufacturing of pellets. Wooden waste must change state of aggregation during pelleting in order to satisfy principles of contradiction from whom the analysis started.
One wooden waste pelleting system must have 4 basic subsystems and 2 additional, not less important, subsystems:
1. System for triturating of wooden waste;
2. System for drying of wooden waste;
3. System for pressing wooden waste;
4. System for cooling wooden waste and
5. System for transportation
6. System for regulation and supervision.

Table 8.

Parameter which is degenerating ⇒ / What are terms for improvement of system? ⇓		*1. Moveable object's mass*	…	*8. Unmovable object's volume*	…	*39. Productivity*
1.	*Moveable object's mass*					*35,3,24,37*
…						
13.	*Object's connections stability*			*34,28,35,4*		
…						
39.	*Productivity*	*35,26,24,37*		*1,35,10,28*		

Table 9.

Parameter which is degenerating ⇒ / What are terms for improvement of system? ⇓		*1. Moveable object's mass*	…	*8. Unmovable object's volume*	…	*39. Productivity*
1.	*Moveable object's mass*					*35,3,24,37*
2	*Unmovable object's mass*			*5,35,14,2*		
…						
39.	*Productivity*	*35,26,24,37*		*1,35,10,28*		

For every system-subsystem of system for pelleting, it is necessary to make variants, i.e. potentially adequate elements for proper, economically payable, ecologically correct working of pelleting system.
Solution 1: At Figure2, it is shown pelleting press (System for wood waste pelleting), with cylindrical strainer which is rotating around horizontal axis. From the inner side of strainer are 3 rollers which are pushing material thru strainer
Solution 2: At Figure3 is solution of pelleting system

which is very often in the world. Strainer is in shape of plate and it is unmovable while the rollers, which are making pellets, are above strainer and create relative rolling on strainer in order to push out material. Solution 3: Exactly the same as Solution 2, with difference in position of rotating axis and existence of cone strainer. This is rare construction because of its small efficiency. Its advantage is that raw material is coming by gravity force to machine.

Figure 2.

Figure 3.

Table 9.

Functions	*Executors*			
	1.	*2.*	*3.*	*4.*
A1. Pressing	*with moveable cylindrical strainer*	*with unmovable cylindrical strainer*	*with unmovable cone strainer*	*with linear press returnable effective*
A2. Getting material in zone of pressing	*using gravity force*	*using shovels on covers*	*using shovels on strainer*	*using shovels on rollers*
A3. Cutting of material	*cutting knives made of steel*	*cutting by hand*	*laser cutting*	-
A4. Getting material out of pressing zone	*using gravity force*	*transportation conveyer*	*manual*	-
A5. drive	*electro-motor*	*gasoline motor*	*Diesel motor*	*vapor power*
A6. Power transmission	*Transmission belt gear*	*Spur gear drive*	*Worm gear drive*	*Helical gear drive*
A7. Regulation and supervision	*manual*	*manual adjustment automatic*	*automatically*	-
A8. Constr. of system	*cast*	*welded*	-	-

These solutions are received bay use of morphological matrix- one-dimensional aligned scheme which indicates explicitly partitioned partial functions of whole system. (Table9.)

From morphological matrix many possible variant solutions can be made, as example:

Var.1: A1-4, A2-1, A3-2, A4-2, A5-1, A6-1, A7-2, A8-2;

Var.2: A1-2, A2-2, A3-2, A4-2, A5-1, A6-1, A7-2, A8-2 etc.

Great number of variant solutions does not have any physical sense, but, there is definite number of variant solutions which should be considered. After choosing variant solutions, approaches to graduation of them, in order to choose the best of them. During grading, in consideration are taken technical and economic criteria. Criteria choosing are created by order of user and manufacturer itself. Complete (economical and technical) partial grade is arithmetical middle of partial grades for every criterion, considered for tri reviewers, at least, experts in their areas. Best variant solution is solution with greatest grade.

Table 10.

Criteria		*Variant solution*			*Grade range*
		1	*2*	*3*	
Technical	*Correctness and security of pressing.*	*3*	*3*	*3*	*1÷4*
	...	*...*	*...*	*...*	*1÷4*
	Reliability	*2*	*1*	*4*	*1÷4*
	Average grade	*3.27*	*3.33*	***3.87***	*1÷4*
Economical	*Number of standard parts*	*3*	*3*	*3*	*1÷4*
	Energy consuming	*4*	*2*	*3*	*1÷4*
	...	*...*	*...*	*...*	*1÷4*
	Product cost	*3*	*3*	*2*	*1÷4*
	Average grade	***3.83***	*2.89*	*3.66*	*1÷4*

3. CONCLUSIONS

Based on previous facts, can be concluded:

1. One of the great problems of wood processing industry is problem of processing and use of wooden waste;
2. This paper gives info about TRIZ method in choose of technology for solving problem of wood waste ;
3. Analysis shows that most economic method is wood waste pelleting;
4. Choose of pelleting machine was done using morphological matrix.

LITERATURE

1. Ehrlenspiel, K.: Integrierte Produktentwicklung – Methoden für Processorganisation, Produkterstellung und Konstruktion. Carl Hanser Verlag, Muenchen, 1995.
2. Miltenović, V.: RAZVOJ PROIZVODA – strategija, metode, primena, Mašinski fakultet Niš, 2003

CHOICE ANALYSIS OF REGRESSION DEPENDED OF YIELD POINT AND ELONGATION OF WELDED CONNECTIONS OF STEEL NIONICRAL-70 AND TEMPERATURE OF THERMAL TREATMENT

Predrag. Dašić, Sava Đurić, Michal Štefánek[1]

Abstract:

In paper is analyzed the dependence regression between yield point Rp and elongation A5 of welded connections of steel NIONICRAL-70 and temperature T of thermal treatment in the form of linear, quadratic, cubic, power, exponential, complex power-exponential and logarithmic regression. On the basic comparative analysis the quadratic regression equation is choused, which correlation coefficient for regression Rp=f(T) is R=0,9146 and regression A5=f(T) is R=0,9573.

***Keywords**: regression analysis, welding, thermal treatment, mechanical properties*

1. INTRODUCTION

Professional public has divided opinions on the need for heat treatment of welded joints after welding. As the speeds of welding and cooling and the time of staying at glowing temperature are very strictly defined, many authors consider glowing temperature to be the factor with the greatest influence on mechanical properties of a welded joint. In the purpose of decision making during the defining of technological procedure of welded constitutions from NIONICRAL-70 in Institute IMK ″14. October″ there was an analysis of normalizing influence on mechanical properties of welded constitution. For making the necessary samples as the basic material tin from NIONICRAL-70 was used, and welding was performed with MIG procedure with filled wire electrode FLUXOFIL-42.

2. TERMS OF TESTING

Mechanical and metallographic examination of samples of welded joint were carried out in the Technical Laboratory of Institute IMK ″14. October″ in Kruševac city, under the following conditions [4-6]:

- *operation:* are welding by MIG procedure with filled wire electrode in protection of gas mixture 80 % A_r + 20 % CO_2;
- *basic material*: fine grained micro-alloyed steel of increased strength NIONICRAL-70, produced by Zelezarna Jesenice city, which corresponds to the quality of N-A-XTRA M70 or WELDOX 700;
- *additional material*: filled wire electrode FLUXOFIL-42 Φ1,2 mm produced by Zelezarna Jesenice city;
- *protective gas*: gas mixture 80 % A_r + 20 % CO_2;
- *row part for welding:* two plates with dimensions ≠16×150×2000 mm, were proposed for welding and preparation was realized by machine work;
- welding was performed with ceramic washer for the purpose of ensuring continual penetration of weld root;
- *preheating of parts:* flame preheating of parts at T_p=190 °C was performed before welding;
- *welding machine:* semi-automat LDA-400 manufactured by Company ″ULJANIK″ - Pula city;
- *welding parameters:* number of welding passes i=3, welding current I=180-220 A, voltage of electric are U=25-29 V, speed of passing of wire $v_ž$=7-10 m/min, welding speed v=9 m/h and flow of protective gas mixture q=15-20 l/min;
- technological procedure of welding with all necessary parameters was made with the application of software system WIS [7];
- *heat treatment of welded joints*: glowing at different temperatures was realized after welding and
- mechanical and metallographic examinations of samples were carried out according to national standard JUS C.A4.004.

During examinations the following properties were observed: yield point R_p in [N/mm^2] and elongation A_5 in [%], the measured values of which, depending on glowing temperature T, are shown in table 1 [4-6], metallographic examinations of macro and micro structure were also performed.

For measured experimental data (table 1) regression dependence was analyzed between:

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Assist Prof. Dr Michal Stefanek, Faculty of Material Sciences and Technology, Trnava, Slovak Republic, E-mail: stefanek@mtf.stuba.sk

Table 1: Table view of measured values of yield points R_P and elongation A_5 of welded constitution of temperature normalizing T

No.	Independence variable T [°C]	Yield point R_p [N/mm^2]				Elongation A_5 [%]			
		R_{p1}	R_{p2}	R_{p3}	$\overline{R}_p$	A_{51}	A_{52}	A_{53}	$\overline{A}_5$
1.	20	671	677	674	674,000	20	24	23	22,333
2.	350	678	679	687	681,333	21	24	23	22,667
3.	450	684	680	702	688,667	21	24	24	23,000
4.	550	662	666	668	665,333	23	24	24	23,667
5.	650	545	569	532	548,667	27	26	27	26,667

- Yield point R_p and temperature T:
  $R_p = f(T)$ and **(1)**
- Elongation A_5 and temperature T:
  $A_5 = f(T)$ **(2)**

In form of: linear, quadratic, (polinomial 2nd degree), cubic (polinomial 3rd degree), power, eksponential, complex scaled-eksponential and logaritmic regresion.

In form of: linear, quadratic, (polinomial 2nd degree), cubic (polinomial 3rd degree), power, eksponential, complex scaled-eksponential and logaritmic regresion. Mathematical process of experimental data consists of determination of numerical values and parameters of linear, quadratic, cubic, power exponential, complex power-exponential and logarithmic regression and correlation analysis of observed equations of regression, which is performed by software [2], which has been described in monograph [3]. In papers [1,3,4] are given some examples of use of this software.

3. DETERMINATION OF PARMETERS OF REGRESION DEPENDANCE RP=F(T)

Equation for linear regression has a form:

$$R_p = 706,4597 - 0,1358 \cdot T \quad \textbf{(3)}$$

which correlation coefficient is R=0,5648, and mean relative error of the experiments is $\overline{\alpha}_{rel}$=6,341 [%].

Equation for quadratic (polinomial 2nd degree) regression has a form:

$$R_p = 661,3818 + 0,4478 \cdot T - 0,000908 \cdot T^2 \quad \textbf{(4)}$$

which correlation coefficient is R=0,9146, and mean relative error of the experiments is $\overline{\alpha}_{rel}$=2,857 [%].

Equation for cubic (polinomial 3rd degree) regression has a form:

$$R_p = 692,0189 - 0,9839 \cdot T + 0,00449 \cdot T^2 - 0,00000509 \cdot T^3 \quad \textbf{(5)}$$

which correlation coefficient is R=0,9981, and mean relative error of the experiments is $\overline{\alpha}_{rel}$=0,435 [%].

Equation for power regression has a form:

$$Rp = 734,1892 \cdot T^{-0,0221} \quad \textbf{(6)}$$

which correlation coefficient is R=0,3367, and mean relative error of the experiments is $\overline{\alpha}_{rel}$=6,827 [%].

Equation for exponential regression has a form:

$$R_p = 710,3672 \cdot e^{-0,000222 \cdot T} \quad \textbf{(7)}$$

which correlation coefficient is R=0,5662, and mean relative error of the experiments is $\overline{\alpha}_{rel}$=6,542 [%].

Equation for complex power-exponential regression has a form:

$$R_p = 461,166 \cdot T^{0,1326} \cdot e^{-0,000974 \cdot T} \quad \textbf{(8)}$$

which correlation coefficient is R=0,8515, and mean relative error of the experiments is $\overline{\alpha}_{rel}$=3,880 [%].

Equation for logarithmic regression has a form:

$$R_m = 726,0831 - 13,4205 \cdot lnT \quad \textbf{(9)}$$

which correlation coefficient is R=0,3336, and mean relative error of the experiments is $\overline{\alpha}_{rel}$=6,659 [%].

Comparative analysis of previus regresion equations of dependance of yield point and temperature: $R_p=f(T)$ is given in table 2.

From table 2 we come to conclusion:

- That only cubic (3rd regression equation in table 2), quadratic (2nd regression equation in table 2) and complex power-exponential regression (6th regression equation in table 2) very good represents experimental data, because the coeficient of corelation R is higher than 0,85 and for the first two regresion equations is significant.
- That cubic regresion equation can adequate describe function of yield ponts R_p and temperature of normalizing T and far best represents experimental data, but phisicaly does not describes real model of research. (figure 1) and
- That quadratic regresion very good describes experimental data and at the same time describes real model of research. (figure 1).

On the bases of analysis of quadratic regresion equation (4) can be chosen, whose coeficient corelation R=0,9146 and mean relative error of the experiments is $\overline{\alpha}_{rel}$=2,857 % and at the same time explains 83,66 % from total variation of dependant variable R_p.

Table 2: *Table view of varius regresion equations of dependance $R_p=f(T)$*

No.	Type of regression	Form of regression equation	R^2	Result of significantly of correlation coefficient for α=10 %				$\bar{\alpha}_{rel}$ [%]
				r	R	R_t	Result	
1.	Linear	$R_p = 706,4597 - 0,1358 \cdot T$	0,3190	3	0,5648	0,8054	insignif.	6,341
2.	Quadratic	$R_p = 661,3818 + 0,4478 \cdot T - 0,000908 \cdot T^2$	0,8366	2	0,9146	0,9000	signific.	2,857
3.	Cubic	$R_p = 692,0189 - 0,9839 \cdot T + 0,00449 \cdot T^2 - 0,00000509 \cdot T^3$	0,9961	1	0,9981	0,9877	signific.	0,435
4.	Power	$Rp = 734,1892 \cdot T^{-0,0221}$	0,1134	3	0,3367	0,8054	insignif.	6,827
5.	Exponential	$R_p = 710,3672 \cdot e^{-0,000222 \cdot T}$	0,3205	3	0,5662	0,8054	insignif.	6,542
6.	Complex power-exp.	$R_p = 461,166 \cdot T^{0,1326} \cdot e^{-0,000974 \cdot T}$	0,7251	2	0,8515	0,9000	insignif.	3,880
7.	Logarithmic	$R_m = 726,0831 - 13,4205 \cdot lnT$	0,1113	3	0,3336	0,8054	insignif.	6,659

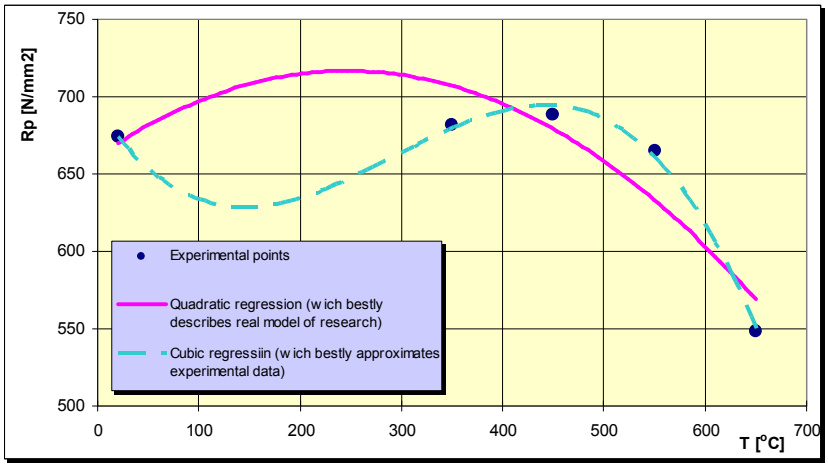

Figure 1: *Graphic view of experimental and calculation values of quadratic and cubic dependence $R_p=f(T)$*

4. DETERMINATION OF PARMETERS OF REGRESION DEPENDANCE A5=F(T)

Equation for linear regression has a form:

$$A_5 = 21,4719 + 0,005435 \cdot T \qquad \textbf{(10)}$$

which correlation coefficient is R=0,7525, and mean relative error of the experiments is $\bar{\alpha}_{rel}$=4,013 [%].

Equation for quadratic (polinomial 2nd degree) regression has a form:

$$A_5 = 22,585 - 0,00899 \cdot T + 0,00224 \cdot T^2 \qquad \textbf{(11)}$$

which correlation coefficient is R=0,9573, and mean relative error of the experiments is $\bar{\alpha}_{rel}$=1,546 [%].

Equation for cubic (polinomial 3rd degree) regression has a form:

$$A_5 = 21,9508 + 0,02065 \cdot T - 0,00008925 \cdot T^2 + 0,000000105 \cdot T^3 \qquad \textbf{(12)}$$

which correlation coefficient is R=0,9961, and mean relative error of the experiments is $\bar{\alpha}_{rel}$=0,522 [%].

Equation for power regression has a form:

$$A_5 = 20,28273 \cdot T^{0,02743} \qquad \textbf{(13)}$$

which correlation coefficient is R=0,5573, and mean relative error of the experiments is $\bar{\alpha}_{rel}$=4,360 [%].

Equation for exponential regression has a form:

$$A_5 = 21,5681 \cdot e^{0,000225 \cdot T} \qquad \textbf{(14)}$$

which correlation coefficient is R=0,7640, and mean relative error of the experiments is $\bar{\alpha}_{rel}$=3,840 [%].

Equation for complex power-exponential regression has a form:

$$A_5 = 28,27094 \cdot T^{-0,083045} \cdot e^{0,000696 \cdot T} \qquad \textbf{(15)}$$

which correlation coefficient is R=0,9310, and mean relative error of the experiments is $\bar{\alpha}_{rel}$=1,976 [%].

Equation for logarithmic regression has a form:

$$A_5 = 20,0144 + 0,6581 \cdot lnT \qquad \textbf{(16)}$$

which correlation coefficient is R=0,5445, and mean relative error of the experiments is $\bar{\alpha}_{rel}$=4,487 [%].

Comparative analysis of previus regresion equations of dependance of elongation and temperature: $A_5=f(T)$ is given in table 3.

From table 4 we come to conslusion:

- That only cubic (3rd regression equation in table 3), quadratic (2nd regression equation in table 3) and complex power-exponential regression (6. regression equation in table 3) very good represents experimental data, because the coeficient of corelation R is higher than 0,93 and for the all regression equations is significant,
- That cubic regresion equation can adequate describe function of elongation A_5 and temperature of normalizing T and far best represents experimental data, but phisicaly does not describes real model of research. (figure 2) and
- That quadratic regresion very good describes experimental data and at the same time describes real model of research. (figure 2).

On the bases of analysis of quadratic regresion equation (11) can be chosen, whose coeficient corelation R=0,9573 and mean relative error of the experiments is $\overline{\alpha}_{rel}$=1,546 % and at the same time explains 91,65 % from total variation of dependant variable A_5.

Table 3: *Table view of varius regression equations of dependance $A_5=f(T)$*

No.	Type of regression	Form of regression equation	R^2	Result of significantly of correlation coefficient for α=10 %				$\overline{\alpha}_{rel}$ [%]
				r	R	R_t	Result	
1.	Linear	$A_5 = 21{,}4719 + 0{,}005435 \cdot T$	0,5663	3	0,7525	0,8054	insignif.	4,013
2.	Quadratic	$A_5 = 22{,}585 - 0{,}00899 \cdot T + 0{,}00224 \cdot T^2$	0,9165	2	0,9573	0,9000	signific.	1,546
3.	Cubic	$A_5 = 21{,}9508 + 0{,}02065 \cdot T - 0{,}00008925 \cdot T^2 + 0{,}000000105 \cdot T^3$	0,9922	1	0,9961	0,9877	signific.	0,522
4.	Power	$A_5 = 20{,}28273 \cdot T^{0{,}02743}$	0,3106	3	0,5573	0,8054	insignif.	4,360
5.	Exponential	$A_5 = 21{,}5681 \cdot e^{0{,}000225 \cdot T}$	0,5837	3	0,7640	0,8054	insignif.	3,840
6.	Complex power-exp.	$A_5 = 28{,}27094 \cdot T^{-0{,}083045} \cdot e^{0{,}000696 \cdot T}$	0,8668	2	0,9310	0,9000	signific.	1,976
7.	Logarithmic	$A_5 = 20{,}0144 + 0{,}6581 \cdot \ln T$	0,2965	3	0,5445	0,8054	insignif.	4,487

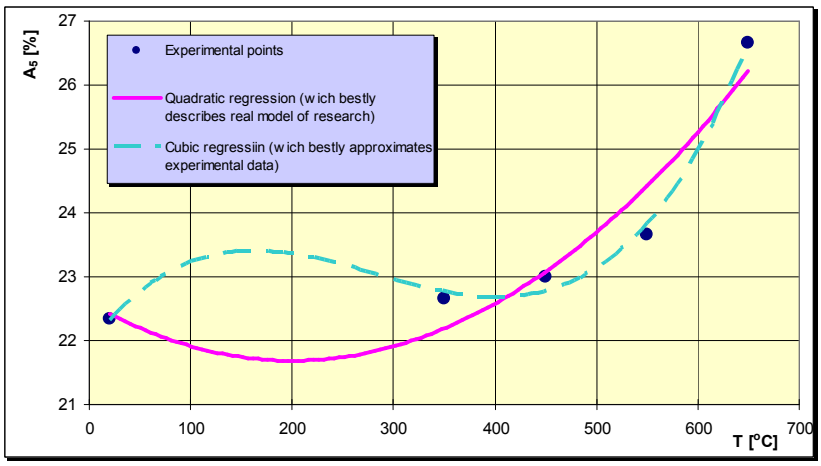

Figure 3: *Graphic view of experimental and calculation values of quadratic and cubic dependence $A_5=f(T)$*

5. CONCLUSIONS

Methodology of comparative analysis and choice of regression equation to coefficient correlation R and mean relative error of the experiment $\overline{\alpha}_{rel}$ is of general character and can it can be used for general analysis of similar process and system dependence.

Experimental data, for the case of dependence determination of yield point welded connection of steel NIONICRAL-70 R_p and normalizing temperature T, represents the best and physically describes quadratic regression (R=0,9146 R^2=0,8366 and $\overline{\alpha}_{rel}$=2,857 [%]).

Experimental data, for the case of dependence determination of elongation of connection of steel NIONICRAL-70 A_5 and normalizing temperature T, represents the best and physically describes quadratic regression (R=0,9573 R^2=0,9165 and $\overline{\alpha}_{rel}$=1,546 [%]).

REFERENCES

1. Dašić P.: *Choice analysis of regression depended on quality characteristics,* 5th Balkan Conference on Operational Research, 22 - 25. May 2000, Banja Luka, Republic of Serbs
2. Dašić P.: Software for choice of regression depended between two variables, ver. 1.0, Kruševac, 2000.
3. Dašić P.: Statistical processing of experimental data, Book 1: One-factoring regression analysis, (monography in preparation in serbian language)
4. Dašić P., Đurić S.: *Regression analysis of influence of heat treatment on mechanical properties of welded connections* (in Serbian language), Journal of Welding&Welded Structures, Vol. 50 (2005.), No. 2
5. Dašić P., Đurić S., Đorđević Lj.: *Optimization of Glowing Temperature of Welded Joint Depending on Mechanical Properties of Steel NIONICRAL-70,* Proceedings of IIIrd International Scientific Conference "Heavy machinery - HM'99", p. 3.104-3.108, 28 - 30. October 1999, Kraljevo, Serbia and Montenegro
6. Đurić S.: *Influence analysis of thermal treatment on mechanical qulities of welded connections* (in serbian language), professional paper, Institute IMK "14. October", Kruševac (Serbia and Montenegro)
7. Đurić S., Marković D.: *WIS - Information system for welding* (in serbian language), XIX JUPITER Conference, Prohor Pčinski (Serbia and Montenegro), 1993.
8. Stanić J.: *Method of engineering measuring, Basic of mathematical theory of experiment* (in Serbian language), Faculty of Mechanical Engineering, Belgrade, 1990. - 250 s.

THE TESTING OF BORIDING FOR THE CASE-HARDENING STEEL QUALITY DETERMINATION

Radmila Pljakić, Radica Prokić-Cvetković, Anđelka Milosavljević[1]

Abstract:

The testings were performed on two groups of the case-hardening steel samples for the purpose of obtaining a surface layer resistant to wear and corrosion. After appliance of the heat and thermochemical treatments, and first of all cementation and boriding, the testing of micro-hardness and microstructure was performed in order to confirm whether the material quality had been improved by the quoted treatments and the required values for application in practice obtained.

Key words: case-hardening steels, boriding, quality, micro-hardness, microstructure

INTRODUCTION

A special place in contemporary technical usage belongs to the technological methods of material treatment relating to forming of surface structures and modification of surface layers including modifications on the level of individual atoms. The addition of boron to the steel surface layer forms compounds of high hardness – *borides* (Fe_2B and FeB). These compounds have a direct influence on the material surface layer wear and corrosion resistance increase.

The advantage of boriding process in relation to others, the application of which increases resistance, is its economy from the aspect of technology as well as the materials subjected to boriding. Practically, all iron-based materials, including those obtained by powder metallurgy, can be borided.

Development of the boriding process is directed to the shortening of duration and quality improvement of the formed diffusion layer, first of all, by providing monophase nature of the very borided layer (Fe_2B boride-based), and also the steel surface simultaneous saturation by boron and other corresponding elements. In the process, the important role of automation, introduction of the observation system and regulation of technological parameters of this aspect of chemical heat treatment are counted on. Besides, it is also important to work on the mathematical modelling, process, boriding for the purpose of enabling design of the process technology and optimization of borided layers forming conditions with the optimal exploitation features or to solve the problem of process management in its entirety.

There are numerous discrepancies concerning the mechanism and kinetics of the process as well as redistribution of carbon and alloying elements present in the steel during the boriding process.

BORIDE CHARACTERISTICS

As the valence $2s^2 2p$ electron configuration in the boron atom is unstable, at forming either elemental boron or its compounds it tends to transform into more stable $2s^2 2p^2$ form, boron in compounds with metals that usually show donor qualities (e.g. iron) behaves as the pronounced electron acceptor. When forming boride, valence boron electrons enter 3d iron orbital. Increase of boron content in borides leads to an increased filling of 3d iron orbital. As a consequence a total strength of interatomic bonds increases going from borides with lower boron content to borides with higher boron content.

Boride Fe_2B is an intermetallic compound with 8,84%B (mas). Its crystal lattice is tetragonal, type $CuAl_2$ with parameters c=0,4248 nm, a=0,5109 nm /1,2,3/ Boride Fe_2B structure is composed of iron atom layers tetrahedrally disposed and mutually bonded and boron atoms filling-up the spaces between these layers, Fig.1

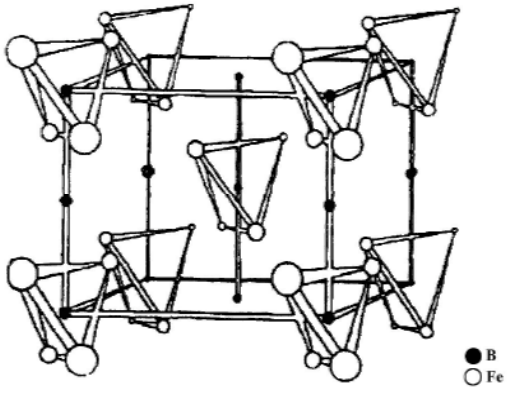

Fig.1 Crystallographic structure of boride Fe_2B /4/

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Intermetal compound boride FeB with 16,25%B (mas.) orthor-ombic crystal lattice with parameters a=0,4061, b=0,5506 nm, c=0,2952 nm /5/. Elementary grid is the projection on a plane (001) shown on a picture 2. ceprehend 4 Fe and B atom, in which process boron atoms along the z-axis mutually form zigzag chains with interatomic distance B-B of 0,177 nm.

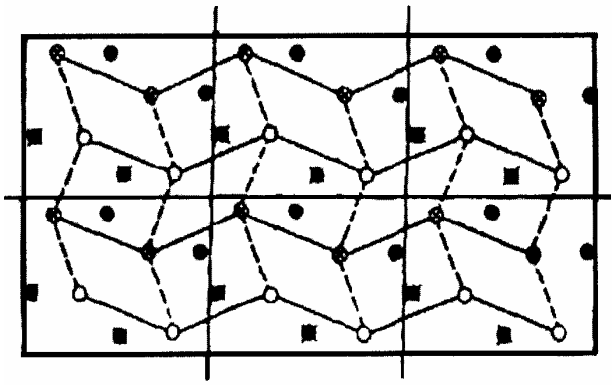

Fig. 2 Crystallographic structure of boride FeB-Projection on a plane (001) /4/

A change of Gibbs free energy while forming Fe_2B compounds can be shown by the following relation:

ΔG^0_{Fe2B}= - 101340 + 20,04T ± 1250 J/mol (1) /6/

A change of Gibbs free energy at forming FeB compounds can be shown by the following relation:

ΔG^0_{FeB}= -93010 + 24,04T ± 250 J/mol (2) /6/

PARAMETERS OF BORIDING PROCESS

Parameters of boriding process (medium for boriding, temperature and duration of boriding) have a quantitative influence on carbon and other alloying element behaviour. Fig.3 shows the influence of carbon content on boron diffusion activation energy, and Fig.4 shows the influence of other steel alloying elements.In Fig.5 is given a layout of chromium disposition in boriding layer.

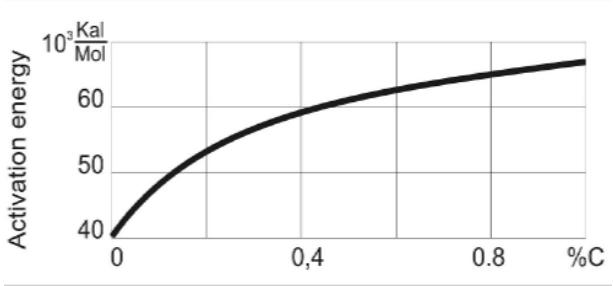

Fig.3 Influence of carbon content on boron diffusion activation energy /7/.

Fig.3 and 4 show that the content of carbon and alloying elements in steel have an influence on the boron diffusion activation energy increase. Mo and W have the most and Mn and Ni the least influence on this increase.

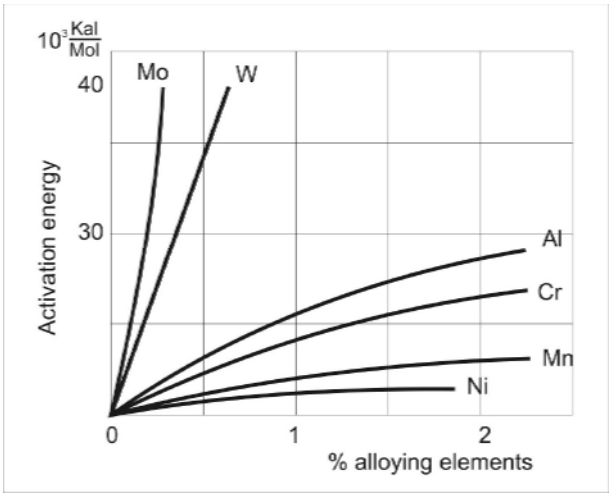

Fig.4 Influence of alloying element content on boron diffusion activation energy /7/.

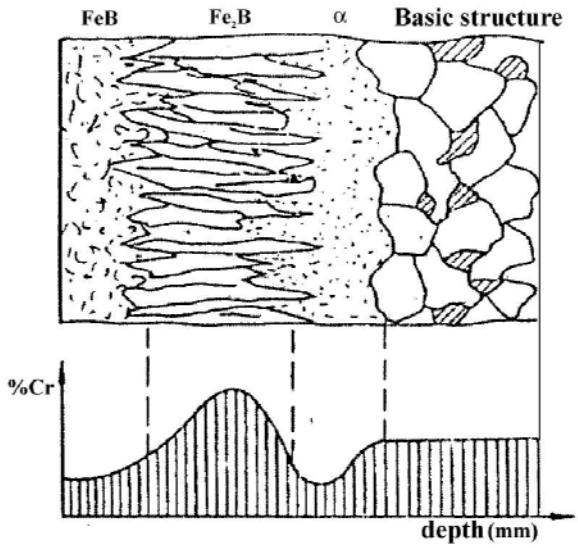

Fig.5 Layout of chromium disposition in boriding layer /8/.

From the basis of the layout given in Fig.5, the pronounced "saw-like" structure Fe_2B with the highest Cr content and it is assumed that Cr atoms from FeB and c- heat-affected zone representing the boron solid solution in iron and located between basic ferrite-perlite structure and the "saw-like" phase Fe_2B, migrate to this zone.

TESTING RESULTS AND DISCUSSION

The testings were performed on two groups of the case-hardening steel samples Č.5421, JUS C.B9.020 and 20X2H4A GOST 4545-71, for the purpose of quality determination and the cemented and borided case depth checking, micro-hardness measurement and metallographic testings. Fundamental difference in contents of alloying elements contents concerned Ni. Ni

Table 1: Required depth values and hardness after performed thermo-chemical treatment

Sample mark	Type of material	Treatment	Required values	
			Depth	Hardness
1	Č.5421 Jus C.B9.020	Cementation Boriding Hardening	1,6 – 20, nm 0,12 – 0,25 nm nucleus	min 58HRC $HV_{0,5} \geq 1500$ 35 – 49 HRC
2	20X2H4A GOST 4543-71	Cementation Boriding Hardening	1,6 – 20, nm 0,12 – 0,25 nm nucleus	min 58HRC $HV_{0,5} \geq 1500$ 35 – 49 HRC

content in the first steel was 1,7%, and in the second 3,65%.

In Table 1 are given required values of depth and hardness after heat and thermochemical treatments had been performed in laboratories of "Prva Petoletka", Trstenik.

Along with specification a care is taken of additional requirements such as:

- Minimal borided case depth should be approximately 0,8 mm.
- Max. 10% deviation from the minimal depth (0,8 mm) is allowed
- Max. allowed flaking of borided case is 7% of the entire surface.
- Specification 173,52.1.TU

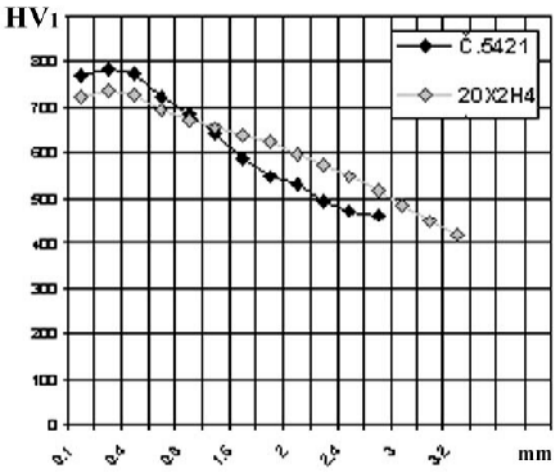

Fig.6 Diagram of measuring results of tested steel case depth (DIN 6773)

Table 2: Measuring results of tested steel case depth

Distance (mm):	0.10	0.20	0.40	0.60	0.80	1.00	1.50	1.90	2.00	2.20	2.40	2.50					Nucleus		
Hardness mm (HV_1):, Line1	770	785	775	724	685	640	590	550	528	495	473	465						465	
Limited hardnes. (HV_1): mm line1	Eht_{550} = 1.9 mm																		
Distance (mm):	0.10	0.20	0.40	0.60	0.80	1.00	1.50	1.90	2.00	2.20	2.40	2.50	3.00	3.10	3.20		Nucleus		
Hardness mm (HV_1):, Line2	721	734	725	695	672	655	639	623	597	575	550	528	485	450	421			421	
Limited hardnes. (HV_1): mm line2	Eht_{550} = 2.4 mm																		

The measurement of case hardness for steel Č5421 JUS C.B9.020 as well as for steel 20X2H4A GOST 4545-71 was performed according to Vickers method HV_1-DIN 6773. The results of hardness measurement depending on the case depth are given in Table 2 and in diagram (Fig.6). Diagram shows that for the steel Č.5421 there is the hardness fall of 0,4 mm after depth measurement, while the steel 20X2H4A mostly shows more even fall.

It is found out that the case depth of the first steel is 1,9 mm, and 2,4 mm of the second steel.

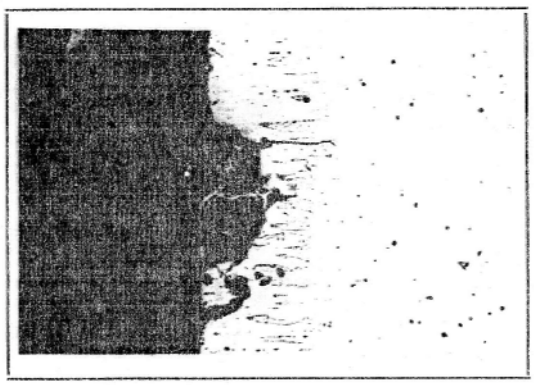

Fig.7 Microstructure of thermo-chemical treated steel Č.5421

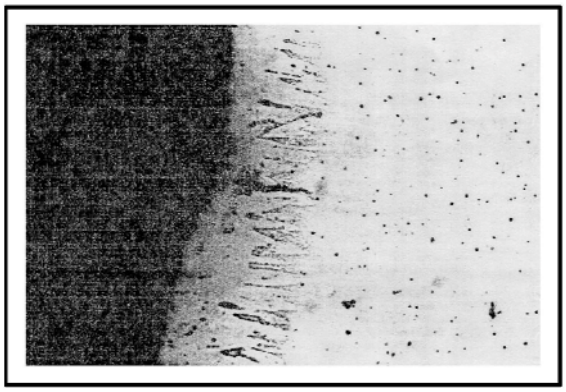

Fig.8. Microstructure of thermo-chemical treated steel 20X2H4A

The borided case depth as well as microstructure are defined mathalographically on an electron microscope. Beforehand polished samples are etched in 3% solution of nital and picric acid. Fig.7 and 8 show the look of thermochemical treated steel microstructure. Shooting was performed along the cross section, immediately at the sample edge.

Fig7 shows the present zone of cemented case as well as the present porousness in the case (the white surface on the right). A borided case with Fe_2B and FeB phase "saw-like" structure is shown along with this zone. The measured depth of cemented case was 1,9 mm, and the borided case depth was 0,12 to 0,2 mm.

Fig.8 also shows the present zone of cemented case with higher participation of porosity (the white surface on the right). The borided case is somewhat more prominent in relation to the previous steel. It also has a "saw-like" structure with higher presence of Fe_2B phase. An increased content of Ni in steel No. 2 decreases boron activation energy, fragmentizes structure and influences quantitative rate increase of Fe_2B phase which has a direct influence on borided case quality. In this case, cemented case depth is 2,4 mm, and borided case depth is 0,12 to 0,21 mm.

CONCLUSION

On the basis of data gained from literature and analysis of obtained results the following can be concluded:

- Measured values of cemented case depth and micro-hardness are in accordance with the demands.
- The presence of Fe_2B phase that essentially influences borided case quality was stated in borided case as well as the presence of less desirable FeB phase followed by microresidual stresses.
- Applied regime of thermo-chemical treatment made it possible to get qualitative structures of tested steels.

LITERATURE

1. Metals Handbook, Vol. 8, Metallograhz, Structures nad Phase Diagrams, AMS, Ohio, 1973
2. G. Palombarini, M. Carbucicchio, J. Mat. Sci. Lett., 4 (1985) 170,
3. L. G. Vorošin, L. S. Ljahovič, G. G: Panič, G. F. Protasevič, Metalloved. Term. Obrab. Met. N^o 9 (1970) 14.
4. H. Kunst, O. Schaaber, Härterei-Tech Mitt., 22 (1967) 1.
5. P. Casadesus, C. Frantz, M. Guantois, Mem. Sci. Rev. Met., 76 (1979) 9.
6. S. Omori, J. Motzama, Trans. Japan. Inst. Metals, 21 (1980) 790,
7. N. P. Ljakišev, Ju. Pliner., S. I. Lappo, Borosoderžaščije Stali i Splavy, Metallurgija, Moskva, 1986.
8. L. S. Ljahovič, E. P. Pučkov,.L. G. Vorošin, E. N. Paltarak, Metalloved. Term. Obrab. Met., N^o 1 (1969) 37.

EXPLORATION OF POSSIBILITIES FOR REENGINEERING OF TECHNOLOGICAL PROCESSES AND MACHINES

Lj. Đorđević[1], I. Filipović[2], D. Đorđević[3]

Synopsis:

Installed equipment for production processes is in service for relatively long period, so it is necessary to undertake its reengineering and adjustment to modern production requirements. If it is possible to achieve and to which technological level, can be answered after each individual case study. Hereunder we presented the results obtained on hydraulic compress in one of our factories.

Keywords: reengineering, technological process, machines and equipment

1. INTRODUCTION

Installed equipment for production processes is in service for a long period. In some production facilities still operating, it's average age is from 20 to 30 years. There is an understandable desire to explore the possibilities of reengineering of existing production equipment, constrained with existing operating capability (funds shortage or unfavourable funding resources). This way, at least our production environment could be closer to modern production facilities.

2. CONDITION OF INSTALLED EQUIPMENT

Table 2.1 gives the oversight of installed equipment in one of forges in our surroundings. There are only machines for deforming and extreme cases of outdated equipment. The rest of equipment is newer, but also over 20 years old.

Table 2.1 - installed machinery and their condition

FACTORY		**IMK"14.Oktobar"-Kruševac**					
Inv.#	*Klass #*	*Nomenclature*	*Type of equipment*	*Producer*	*Year of production.*	*Condition*	*Total # of this machines*
64-1441	253.0.642	Eccentric compress	EP-150	ILR-Železnik	1955	working	21
64-1447	254.0.476	Hydraulis compress	IWK-630	ERFURT	1958	working	23
73-1436	252.0.644	Friction compress	FP-150	ILR	1952	working	7
72-2600	203.0.544	Steam-air hammer	MPM-5000	HUTA ZYGMUND	1967	working	7
FABRIKA		**FABRIKA VAGONA KRALJEVO**					
637	52-D	Friction compress	100 tona		1926	working	8
634	51-A	Eccentric compress	100 tona		1938	working	6
1413	57-A	Air hammer	500 kg		1930	working	6

3. REENGINEERING OF HYDRAULIC MACHINE FOR EXTRACTING HVO-2-250

The data given above has a goal to show that it is necessary to undertake adequate reengineering, so certain functions could be updated. Machine in this example was installed during the sixties and is currently operating in company ALFA-PLAM in Vranje. It is a hydraulic machine for extracting HVO-2-250, manufactured by Litostroj Ljubljana with following basic technical

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characteristics:

- max extracting force 250 t
- compress motion 800mm
- cushion motion
- working desk dimensions 1250 x 1250 mm
- cushion dimensions 1000 x 1000 mm
- Compress dimensions 3,1 x 1,8 x 6 m

Mentioned automation can be applied on the following compress functions:

3.1. Warming up period

Warming up is running in first 10 seconds after powering up the compress and informs the operator that the machine is operational, displaying its basic functions on LCD display.

3.2. Screens that are not password protected

After worming up period of compress, the green LE diode on the terminal is turning on displaying the basic screen where, by pressing DATA key, other non pasword protected options can be seen. Display is always beggining with basic working screen showing number of processed pieces. Other data, displayed on figure 3.2, can be accessed also:

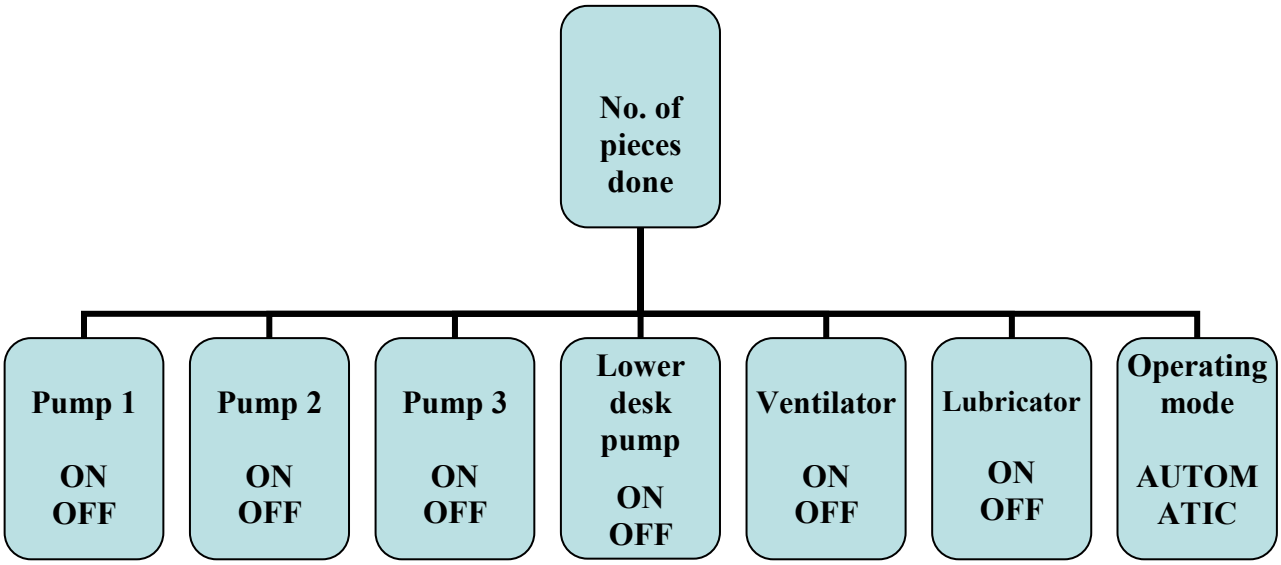

Figure 3.2. Operational informations for machines with non pasword protected display

If there wasn't any key pressed for 10 seconds, display will automatically show the screen with No. of pieces done, the same screen as shown on top of figure 3.2 which is memorized even after the machine is turnd off.

3.3. Password protected screens

The purpose of screens that display data only after the correct password is entered is to enable changing of certain working parameters only to an authorized personnel only. Possible combinations are given on figure 3.3.

If there wasn't any key pressed for 10 seconds, display will automatically show the screen with No. of pieces done, the same screen as shown on top of figure 3.3 which is memorized even after the machine is turnd off. Time can be adjusted in range from 0-999.9 sec. by pressing UP and DOWN keys, and input must be confirmed bu pressing ENTER key. To display password protected screen, press REG key.

3.4. Alarm screens

Alarm screens are intended to inform the operator of eventual anomalies or alarm states of machine. Alarm screen is displayed directly after the alarm state occurrence and stays as long as alarm state exists. Alarm state is additionaly signalized with turning off green LE diode on terminal which marks regular machine state and turning on red LE diode on machine terminal.

If there are multiple alarm states, only one with the highest priority is shown (figure 3.4.)

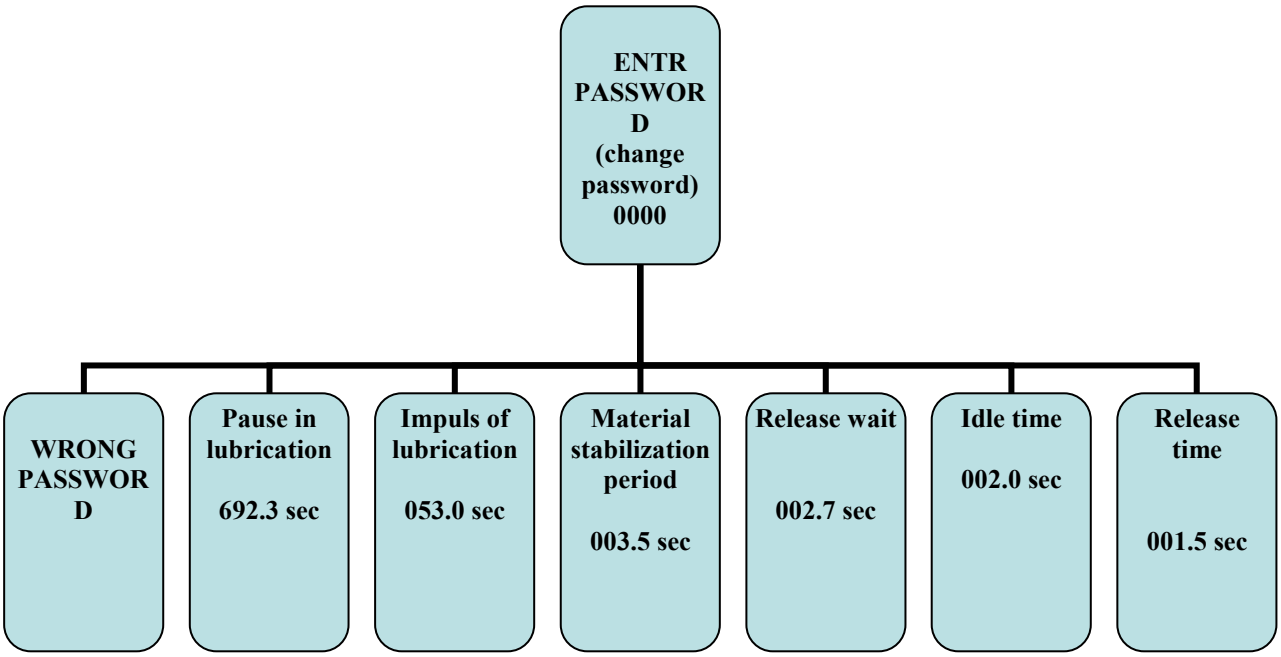

Figure 3.3 – Display on password protected screen

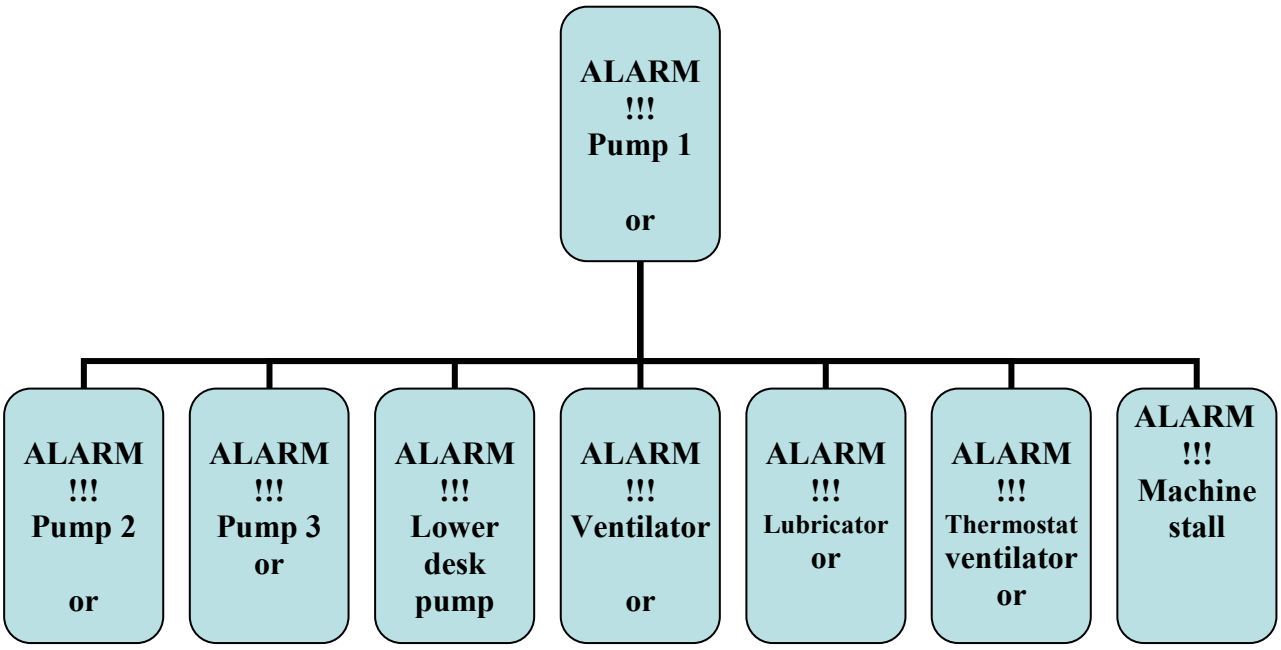

Figure 3.4. Alarm screens

4. Built-in components

Automatization of compress operation is achieved with embedding of Programmable logical controler (PLC-OMRON CQMIH), with modular construction built in electrical locker of KP-250 compress, which consist of:

- power supply module CQM 1-PA 203
- CPU module CQM-CPU61
- Digital input module CQM1-ID212
- Digital output module CQM1-OD212
- Power source S82K-05024

As additional detail of whole process, the electrical diagram of Pump 1 and its installation is given on figure 4.1.:

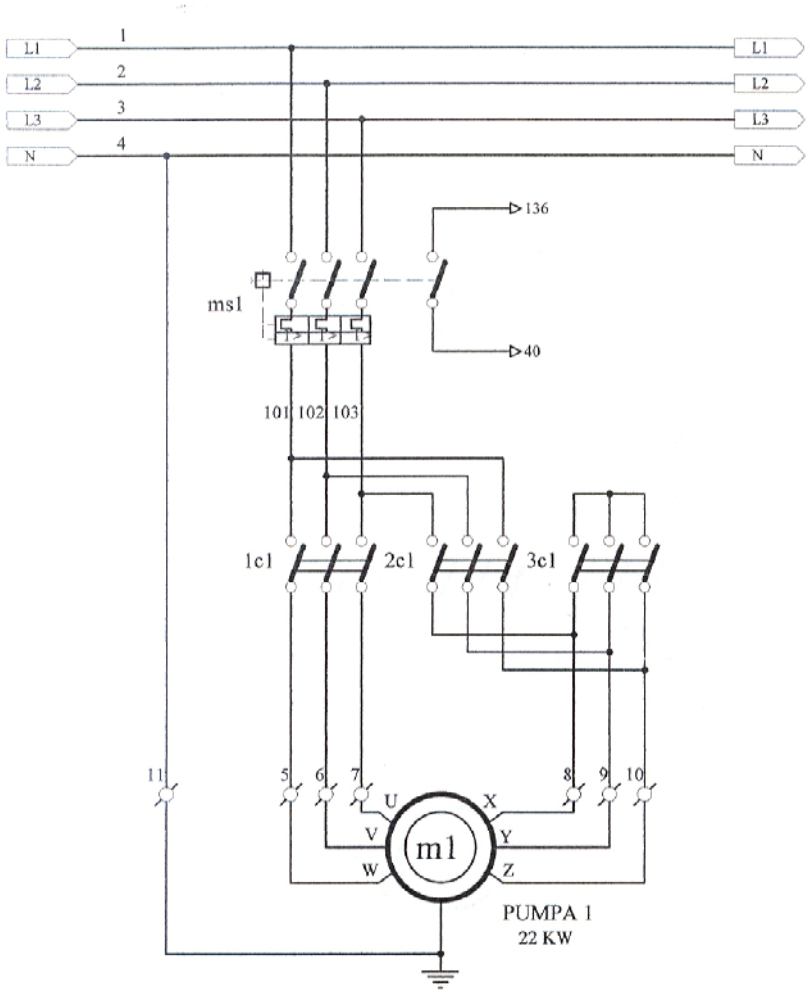

Figure 4.1. Electrical diagram for installation of Pump 1

5. RECAPITULATION

Analysis of reengineering of installed equipment should be done for each machine separatelly, in order to justify the investment in reengineering. It can be seen that some of machines operating are in very bad shape, so there can't be an interest in their reparation or automatization.

6. LITERATURE

[1] Revitalizacija automatskog upravljanja hidraulične prese, KB3534A (KP-250), Tehnička dokumentacija firme **IC SISTEM,** Kruševac.

THE ASPECTS OF QUALITY AND ECOLOGY IN THE PROCESS OF BORONIZING STEEL MATERIALS

Radmila Pljakic, Andjelka Milosavljevic, Jovan Manasijevic[1]

Abstract:

This work demonstrates results of the process of boronizing with solid agents. Here are observed the essential parameters that influence over quality of boride layer. Analysis of the ecological aspects of process of boronizing was performed and their affect on process applying. Analyzing the law regulative that is referred to by its manufacturer, which obligates customers, it can be concluded that the costs of boronizing process are lower than the costs of ecological releasing of the solid waste products formed during the process of boronizing. Emphasis is set on introducing more contemporary processes of boronizing, lower costs of treatment, and thus the costs of ecological releasing of solid waste products that remain after multi-usage of boronizing powder.

Key words*: Boronizing, ecology, quality, solid agents, steel materials.*

INTRODUCTION

Main contents of the work is based on the results of investigation, identification and observation of the process of boronizing in the enterprise "Prva Petoletka-TMO AD" Trstenik and an attempt of releasing used "Durborid 2" powder that remained as solid waste product after process of boronizing.

It is well known, in comparison with the other processing, that this process is very simple/1,2/ to work, but very complicated from the view of aspects of ecological releasing boronizing by-products, and that is, actually, useless granule that remains after multi-applied "Durborid 2" powder /3/.

Since that is a high temperature process and that the percent of ecological waste products is high, there is a danger of injury since the process is performed manually, it is not automated.

Because of that, it is necessary to intensify investigations, and apply world experience in introduction of new, clear processes and technologies /4,5,6/, that we are in obligation by Europian and national conventional standards.

PROCESS OF BORONIZING

Powder-pack boronizing belongs to the group of diffusion thermo-chemical process and leads to improvement of physical, chemical and tribological characteristics of the surface harden layers of steel materials.

Boride layer formed during powder-pack boronizing has been used in conditions that request high hardness, high wear and corrosion resistance of parts. The process of boronizing takes place in simple equipment (chamber furnace) in which are placed boxes designed for that. Parts prepared for boronizing are packed in those boxes. Economization of the boronizing process is influenced by numerous factors: a temperature gradient, powder concentration, powder composition and ecological releasing of solid waste products formed in the process of boronizing. To make the process of boronizing economical and boride layers of good quality, our experience shows that the optimal temperature is 900°C. Minimal boronizing time is 13hrs. Air cooling time is 10hrs. Quality control of the boride layer performs according to proper procedure by the customer, for determined types of parts and determined technological process.

It is important that finding the optimal process of boronizing follows examination with investigation-development character /7, 8, 9, 10/.

ECOLOGICAL ASPECTS OF THE PROCESS OF BORONIZING

LAW BASE

Boronizing powder consists of borides of various compositions as boron basic compounds, and some other unknown compositions, and because of that is under the regulations about deposition of solid waste products formed during the process of boronizing.

Because of that powder the manufacturer gives instructions about destroying solid waste products as that is about dangerous matter and demands respect of regulations valid for dangerous matters.

Manufacturer, in this case a foreigner, refers to respect "Law about removing the waste products".

In the time when "Prva Petoletka – TMO AD" did the procedure under driving conditions, the boronizing

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agent manufacturer offered a solution to his customers, e.g. releasing the solid waste products using the – "manufacturer" as a third party.

There was a condition – to maintain the line of direction given by the manufacturer and these consists of instructions on how to: collect, clarify, mark, pack and transport solid waste products.

On that occasion the manufacturer refers to the following regulations:

- Regulations about transporting dangerous matters on the roads;
- European agreement about international transporting dangerous matters on the roads;
- Regulation about transporting matters by railway.

That means that packages containing solid waste products should be classified in the way showed in Table I

Table I and Table II "Line of direction by manufacturer". The lines of direction further order transport and deposition of solid waste products order should be directed to the manufacturer's address by mail.

The order has to contain the exact weight and type of solid waste products data.

- Transport of solid salt residue is to be done by an authorized company that has permission for this type of work.
- Customer task and law duty is to respect law regulation of both, his and manufacturer's country.
- For re-delivery of solid waste products, the paragraph from law regulative is relevant.

Type of solid quenching salt residue (manufacturer's mark)	Laying out the barrels using oil paint according to transport regulations	Composition
From the solutions containing the following durferrit salts: C1, C2, C3, C4, C5, C6, C7, CECOSTANT® GS 430, 520, 540, 560, 660, 750, 960, A4, A5 R2, R4 Carboneutral, Semperneutral, Sediment from TF1 NS1, NS2, NS3 NS – Rotring From the solutions containing the following "Effge" salts: cisol, olesol, cyanol, all duasal salts RA, EAS, GS 43, 52, 54, 65-69 Neutral 54, Neutral 70, Constant, Sintert - Polluted brick for furnace lining	DC (minimal letter size 15cm) using water-resistant paint: (oil paint) Customer's number: Warning stickers No. 6.1 (dead head)	3-4 % sodium – potassium cyanide 2-45 % sodium – potassium cyanate 3-40 % barium- carbonate 3-37 % barium – chloride 5-25 % sodium – potassium – chloride 5-25 % sodium – potassium - carbonate

Example for salts marked "DC"

Solid waste products marked as "DC" have to be described in a load sheet as following:

"Salts for the heat treatment: used

Transport technical name: waste products consists of sodium- potassium – cyanide

Class 6.1. No 41a, GGVE, GGVE, GGVS, RID, ADR

Very poisoned matter!

Keep separately from food products, and acids."

Salt residue marked as "DW" has to be described in a load sheet as following:

"Salts for the heat treatment: used

Transport technical name: waste products consists of hydroxide – nitrite – and nitrate of alkaline metal

Class 8, No 65b, GGVE, GGVS, RD ADR

Corrosive, flammable (oxidizing) solid material".

TRANSPORTATION AND DEFERMENT COSTS

The costs of qualification, transportation and deferment are paid by the customer, and to both, the firm that does transportation and the firm that does deferment of dangerous matter.

By disregarding "manufacturer's lines of direction" customer bears not only costs of deposing but he responds for damages caused by disregard or their offence.

RULES REGARD TO SOLID WASTE PRODUCTS

Disregarding or offending manufacturer's law, decree, regulation, line of direction or instruction on the

customer's part with regards to deferment waste products, with no means if it is purposely or not, the manufacturer is entitled to take necessary steps against the customer. The manufacturer would demand amends for every damage made to the third party.
In unclear events the customer is in an obligation to prove the regularity of his behavior, that is regularity of delivery.

Table II

Type of solid quenching salt residue (manufacturer's mark)	Laying out the barrels using oil paint according to transport regulations	Composition
From the solutions containing the following durferrit salts: AS 140, 220, 235, 300 GS 230 AVS 250 TR155 KOLENE® - salt residue from AB1 SR700 From the solutions containing the following "Effge" salts: AS 1,2,3 GS 23 AVS 22,25 ASD Cleaning salts Salts for blackening	DW (minimal letter size 15cm) using water-resistant paint: (oil paint) Customer's number: Warning stickers No. 8 No. 5 (8) (reagent of a bottle with the drop on the plate and hand) (5) (flame beyond the circle on the yellow base, secondary danger)	3-40 % barium – carbonate 3-37 % barium – chloride 5-25% sodium – potassium-chloride 5-25% sodium – potassium-Carbonate 20-30 % sodium – potassium – nitrate 20-30 % sodium – potassium – nitrite 10-80 % sodium – hydroxide 10-80 % potassium – hydroxide

RETURN OF SOLID WASTE PRODUCTS

Manufacturer is, except in the events anticipated by law, entitled to return irregular parcels.

a) If, from the customer part, delivered waste products is not according to regulations.
b) If the customer neglects the law or regulation, line of direction or individual instruction given by manufacturer.
c) If the deferment, not due to reasons that manufacturer represents, is not possible to realize or it is impossible to demand for it.

If the customer is a person or a firm that does trading, the court in the country of manufacturer is authorized; and for manufacturer's complaints that is customer's court.

Considering the previous, ecological aspect would be particularly significant in developing plasma technologies, because in applying those technologies the risk of pollution of human environment can be reduced to minimum or absolutely eliminated.
In applying plasma deferment layers, that is particularly important that using various combinations of number and quality of surface layers can increase wear resistance, fatigue and cracking resistance on surface layer and corrosion resistance.

All of this with achieving low friction coefficients provides wide possibility of applying plasma deferment layer in modern industry, although the cost of involving new technological methods in serial production is relatively high.

CONCLUSIONS

1. In consideration of well-known circumstances, until now, according to author's knowledge, there is no permanent solution for deferment, refining or destroying solid residue of used salts.
2. Comparing the costs of storing, transporting and deferment waste products after the process of boronizing and by applying regulative laws with the total costs, there is need for further work to find cheaper ways to deferment and recycle solid waste products after the process of boronizing.
3. It is necessary to continue examinations for the purpose of finding cheaper ways of ecological releasing of the existing problem amassed waste products, either by engaging the manufacturer, or in own condition. More detailed information can be found in tandards, regulation or corresponding internal documentation "Prva Petoletka – TMO.AD. – TRSTENIK.
4. Since this involves a high temperature powder-pack process of boronizing it is necessary to expand and apply world-wide experiences and involve new, cleaner processes and technologies that we are obligated to, under conventions and standards on national and world level.
5. According to previous analysis about quality and ecology aspects, anticipate is an introduction of deposition solid layers using plasma processes, where the preference is given to ion beam technologies.

REFERENCES:

1. Uputstvo za boriranje Degussa, Hanau, Trstenik 2500;
2. Interna dokumentacija (standardi, norme , pravilnici, protokoli, uputstvo , katakozi... Trstenik 2005 god.
3. Standardi serije ISO 9000 ili ISO 14000 , DIN Standardi, GOST idr
4. Elders J. , at all., Surf. and Coat. Techn., 45 (1991) 105-109
5. Hatto P., Vacuum., 36 (1986) 67.-71.
6. Boxman at all., J. Appl. Phys, 54 (1983) 592.
7. J. Gilman, J. Appl. Phys. 41, (1970) 58-64.
8. M. Ahern, Surf. and Coat. Tehnol. 43/44 (1990) 279-287
9. H. Ronkainen at all. Coat. Tehnol. 43/44 (1990) 888-897
10. M. Murakama at all, Surf. and Coat. Tehnol. 43/44 (1990) 145-153.

ECONOMY AS ONE CRITERION FOR THE SELECTION OF THE AUTOMATION LEVEL OF PRODUCTION EQUIPMENT

Dragan Živković[1], Đorđe Zrnić[2]

***Abstract**:*

This paper considers the selection of an optimum automatiyation level of production equipment. There is a multitude of criteria on basis of which the selection of an optimum automation level can be done. One of those criteria, not the most important, is economy of production equipment . There has be done an analysis of 317 technological operations divided into forty-one group (group technology), in the factory "Zmaj" .The results, the dependence of economy on the automation level of production equipment, are shown in this paper.

***Keywords:** Economy, automation level, production equipment,*

1. INTRODUCTION

The purpose and goal of optimization of the automation level of production equipment is achieving greater efficiency of the production process, and the enterprise as a whole. Greater efficiency implies greater income too, and it is in the interest of any enterprise to increase their income. Income is the material basis of existence and development of an enterprise. Increase of income can be achieved by increasing the volume of production or by decreasing the cost of production. Efficiency of production can be evaluated by the amount of assets engaged in the realization of production, and also by the working resources and the level of their rational employment, because it is a big difference if income will be realized with lesser or bigger production means. Consequently, the goal of an enterprise is to create bigger income by engaging financial assets as rational as possible, i.e. :

- to achieve a maximum volume of production and income by minimum use of labor force.
- to achieve a maximum volume of production and income with minimum cost.
- to achieve a maximum volume of income by minimum engagement of production means.
- to achieve a maximum volume of production with a minimum amount of working time.

The basic principles of the profitability of an enterprise, i.e. the efficiency of production:

- Productivity
- Economy
- Profitability

2. ECONOMY

Economy of labour is the ratio between the achieved amount of production and the production costs. The ratio between the production amount and its costs is the level of economy of production. In mathematical terms, that is:

$$E = Q / T \quad (1.)$$

and

$$E = Q / (T_{RS} + T_m + T_{SR}) \quad (2.)$$

where is:

T (€/h) - Production costs
T_{RS} (€ /h)- Labour force costs
T_m (€ /h) - Material costs
T_{SR} (€ /h)- Costs of labour equipment

If the production increases, and the costs for this production are decreasing, then the economy of production is higher. In other words, the level of economy increases when the the costs per unit of production are decreasing.

Costs of labour equipment. When selecting production and transportation equipment there should be saved as much time and money as possible, to decrease the amortization period, to increase profit and productivity, and decrease maintenance and exploitation cost. Factors that affect working costs of production or transportation equipment are numerous. To make the right choice, it is necessary to make detailed analysis of all the relevant factors, which build the exploitation price of the selected production and transportation equipment.

The basic structure of costs of production and transportation equipment (invested equipment) is as follows:

1. Working equipment costs
1.1 cost of amortization (Ta)
1.2 maintenance costs (To)
1.3 cost of tools and accessories (T_{AP})
2. Energy costs
2.1 cost of fuel and energy used (T_{eA})
2.2 cost of lubricants etc. (T_M)
3. costs of foreign services (T_{SU})
4. costs of interest rates and insurance (T_{ko})

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5. cost of labourers (T_{RS})
6. cost of working space (T_{RP})

Consequently, the structure of production i.e. transport equipment exploitation costs, mathematically expressed, is:

$$T=Ta+To+T_{AP}+T_{eA}+T_M+T_{SU}+T_{ko}+T_{RS}+T_{RP} \quad \textbf{(3.)}$$

Depending on the unit used for presenting particular, previously explained costs (mainly in dinar or €) and on the time period within which these costs have been observed (mainly year, month, day or hour) we get the exploitation costs of production i.e. transport equipment in corresponding units.

3. AUTOMATION LEVEL OF THE PRODUCTION EQUIPMENT

Automation of the production equipment i.e. of production system has the task

- to reduce physical effort of a man,
- to increase productivity,
- to increase product quality,
- to increase economical efficiency.

As a measure of automation for production equipment - machine, production process i.e. production system most frequently is used one measure named: level of automation. The automation level represents the relation of the number of automatizated functions to total number of functions and can be determined by means of the formula: [1.]

$$A^0=A_f / A_u \quad (4)$$

where:

A° - Automation level

A_f - Number of automatizated functions

A_u - Total number of functions

Since nowadays is present a great number of different production equipment having available quite considerable variety of construction and technological characteristics it is therefore very difficult to make comparisons between them. In order to determine the number of automated functions and their comparing the sorting of their single characteristics can be done in different ways. One of them, neither the only one nor the final, is as the following: [1]

The automation level is one relative measure of the automation which shows the development phase of managing information to which all changes are automated. For example: the automation level would be as follows: for a radial drill 0,12 for a radial drill with a circular table 0,15, for a horizontal drilling and milling machine 0,17, for a machining centre 0,48.

4. ANALYSIS OF ECONOMY OF A CHOSEN AUTOMATION LEVEL OF PRODUCTION EQUIPMENT

An analysis of 317 technological operations was conducted, divided into forty-one group (group technology), in the combine factory "Zmaj", and we got the following results (table 1. for production equipment, and table 2., for transport equipment):

Economy of labour, as we have mentioned already, is the ratio between the achieved amount of production and the costs of production, and can be determined from the equations: (1. and 2.). Average values for the following parameters Q- max. number of pieces per year and T- production costs , and the corresponding level of labour economy -E., are shown in table 4:

On basis of the results given in table 4., we can draw a diagram of interdependence of economy and automation level of production equipment.(figure 1).

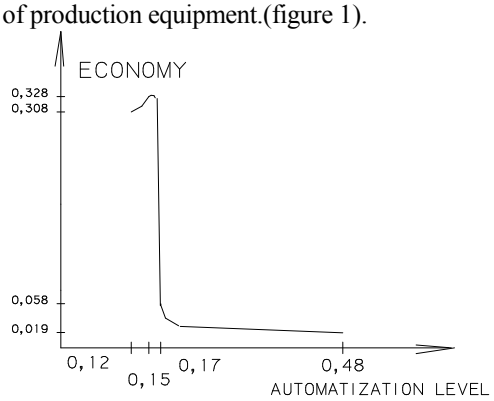

Figure 1. Diagram showing relation of productivity to the automation level of production equipment

From the diagram which shows the relation between the level of economy and the automation level of production equipment we can see that the economy of labour does not necessarily increase with the increase of the automation level of production equipment. On the contrary, the economy function curve has an extreme value which shows the optimum automation level of production equipment. The reason for this is that the costs (price) of production equipment with a higher automation level increases much faster than the productivity when working with this equipment. CNC production equipment is in average 5 to 10 times more expensive and 1,5 to 4 times more productive than tool machines which are manually controlled. The objective is to work with a better level of economy, and a less expensive production.

The resulting curve of interdependence between economy and automation level of production equipment we can approximate by a curve for which the equation (5.) is:

$$y= a +b/x + c/x^2 \quad (5.)$$

where: a= 206,317; b=-54,97 c= 3,672

The approximated curve is almost identical with the curve of interdependence between economy and automation level of production equipment.

On basis of equation (5) we can follow the change of one parameter (economy or automation level of production equipment) when the other parameter changes. This contributes to easier decision-making in the combine factory "Zmaj" when selecting optimum technology, and the optimum automation level of production equipment which will be used for the realization of the product.

Table 1. Exploitation costs for production equipment

	Radial drill	Rad. drill with revol. table	Horiz. drill and mill	Machining centre
Autom.level	0,12	0,15	0,17	0,48
	Average duration of an operation cycle (min./piece)			
operat. 1	-	-	62,0	45,0
operat. 2	7,8	7,3	7,1	6,9
operat. 3	10,2	9,7	9,5	9,3
operat. 4	10,2	9,7	9,5	9,3
	Total cost of operations 2,3 and 4 (€ /piece)			
	2,2	2,7	16,9	51,5

Table 2. Exploitation costs for transport equipment

	Radial drill	Rad. drill with revol. table	Horiz. drill and mill	Machining centre
Autom.level	0,12	0,15	0,17	0,48
	Average duration of a transport cycle (min./piece)			
operat. 1	-	-	0,15	0,15
operat. 2	0,6	0,2	0,15	0,15
operat. 3	0,6	0,2	0,15	0,15
operat. 4	0,6	0,2	0,15	0,15
	Total cost of transport operation 2,3 and 4 (€ /piece)			
	1,05	0,35	0,26	0,26

Table 3. Costs as a function of the automation level of production equipment

Tzpe of costs (€ / h)	Automation level			
	0,12	0,15	0,17	0,48
T_a –Amortization costs	0,475	0,725	7,456	26,316
T_O –Maintenance costs	1,037	1,585	15,65	55,261
T_{AP}-Tools and equip. costs	0,14	0,22	2,23	7,9
T_{eA} –Energy costs	0,13	0,13	0,246	0,5
T_M –Lubricant costs	0,013	0,013	0,025	0,05
T_{ko} –Inter. rates a. insurance	0,826	1,27	7,38	26,18
T_{RP} –Work space costs	1,2	1,2	5,00	4,6
T_{RS} –Costs of labour force	0,873	0,873	0,873	0,328
T_{RS} +T_{SR}- costs	4,694	6,016	38,86	121,135

Using the results shown in table 2, we can produce a diagram (figure 2) which shows the relation between internal transport costs and the automation level of production equipment, as well as their position from the aspect of the economics of the production process.

The correlation shows in the part where the automation level is based on the aggregation of single production operations. Where the automation level is a result of the automation of control operations this correlation is very weak. By defining this correlation we make possible a more economical choice of technological operations and the choice of a optimum automation level of production equipment.

Table 4. Level of economy as a function of the automation level of production equipment

	Radial drill	Rad. drill with revol. table	Horiz. drill and mill	Machining centre
Autom. level	0,12	0,15	0,17	0,48
Q-Max. number of pieces per year	5745	5955	6207	6141
Operation costs of prod. equip. (€ /piece)	2,2	2,7	16,9	51,5
Transp. costs (€ /piece)	1,05	0,35	0,26	0,26
T-Total costs (€ /piece)	3,25	3,05	17,16	51,76
T-Total costs (€ /year)	18 671	18 163	106 512	317 858
E- Level of economy	0,308	0,328	0,058	0,019

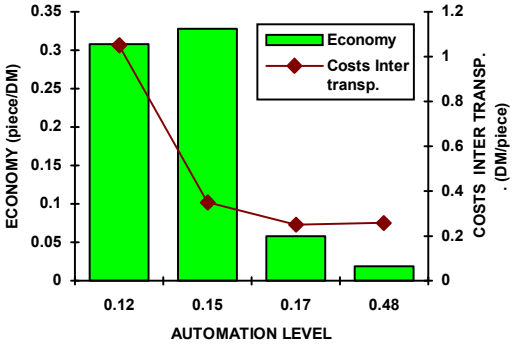

Figure 2. Relation between costs of internal transport and costs of production equipment and their influence on the economics of the production process

5. CONCLUSION

By establishing a relation between economy and automation level of production equipment, helps with the selection of a suitable technology, i.e. selection of a optimum automation level of production equipment. Of course, it is important to stress that economy is not the only, nor decisive criterion for the selection of technological operation, and the automation level of production equipment. Economy can only be one among the many other criteria. Their analysis can contribute to the selection of an optimum technological operation.

6. REFERENCE

1. Živković, D: Productivity as one of the criteria for selection of automation level of production equipment, 3rd International conference Research and Development in Mechanical Industry-RaDMI 2003, H.Novi, 2003, p.p.1148-1153**.**

2. Zrnić.Đ: The influence of thetransportation system modelling to the system elements performances and development of their construction, *Scientific Meetings of the Serbian Academy of Sciences and Arts*, Vol. LXXXIII. Department of Techical Sciences,Book 2, 1996, pp 573-586, Belgrade.

3. Zrnić, Đ: Some problems of modelling the complex material flow system, In: Manufacturing Systems: Modelling, Management and Control, Ed. by P. Kopacek, PERGAMON (Elsevier Science), Vienna, 1997, pp. 429-434.

MODERN APPROACH IN DESIGN AND EXCHANGE OF INFORMATION WITHIN THE MATTER OF A PRODUCT LIFECYCLE[1]

Arandjel Babic, Aleksandar Zukovski[2]

Abstract

The aim of this paper is to represent a model of exchange of information at the level of product lifecycle. The basic technologies functioning within PLM(Product Lifecycle Management),of which first of all are Parasolid and XML, have been analised in this paper. The design and exchange of information are based upon the complex models which include management in exchange of information between the particular phases of engineering design and the product lifecycle.

***Key words**: PLM, XML, Parasolid, HTML*

1.THE BASIC POSTULATES OF EXCHANGE OF INFORMATION ON WEB TECHNOLOGIES-BASED PRODUCT

Serial production makes the most of world industrial production nowdays. It makes 60-80 % of all production.The main difficulties in serial production arise from the great varieties of products and the small output series. Product variants cause to designers the problem of designing the large assortment of different parts. The decisions made at the designing stage significantly affect product costs, quality and time needed for product`s arrival on the market. It leads to: high investments in equipment, milling cost increase, prolongation of production preparation time, needless material wastage and high quality control costs.

Solving of this problem is based upon formation of modern Web technologies-based informational system., first of all upon XML protocol. The consortium, in charge for internet W3C development, managed to excel client-server logic,outdated within business, by developing of XML technologies and, in that way, to improve the two-way exchange of information on the product. XML is object-oriented structural language which main advantage, in relation to HTML, is its independence from Browser. The architecture of Web application by means of XML is illustrated in the figure 1.

HTML says very little about the data structure which it shows, that means it enables us to enter the sructural data in regular tables with.: headings,rows with particular entitled columns and rows in which data is entered. In addition, it is very important to emphasise that in such organization HTML does not give relation between entitled columns and data. Structuring data by XML, a purpose is given to a classic table which becomes very intelligible object-oriented model. Such approach makes the programmers` job much easier. That means that the most of the programming languages have the basic data structures included in language specification – relational lists, vectors, coorelations, but all of them mainly represent linear structures. The problem of representing the tree diagram structure is that consistent methodology for design of such structures does not exist, thus it is necessary to program the technics for tree diagram fullfilment, navigation, searching for elements, etc.

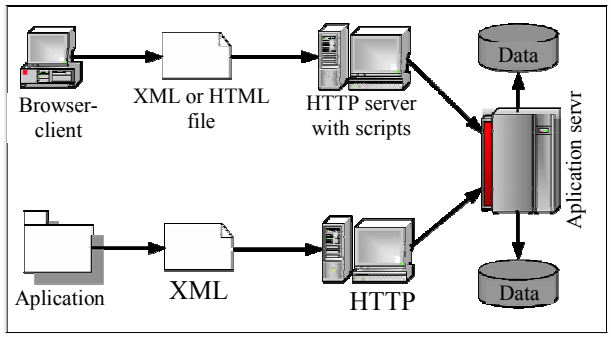

Figure 1. Arhitecture of Web application using XML

In order to transform the XML document in a form suitable for representing the data which it contains, there are the mechanisms, as the XML technology`s subset, which enable suchlike conversion, and they are to be defined using XSL. This language support XML

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documents transformation in other forms such as HTML, SQL scripts, etc. In terms of theory, XML should be able to transform XML document data in any form.

The basic role and advantage of exchange of information on manufacturer-customer relation at XML technology level is that the customer simply can generate his demands using internet. That is, the customer can put forward his demands by simple fullfiling the form defined by JAVA platform, which is available on the site of a company. The demand defined in this way, by XSL protocol, is transformed in XML, which,upon integrated XML, generate in application the product variant on customer`s demand. The scheme of this approach is illustrated in the figure 2.

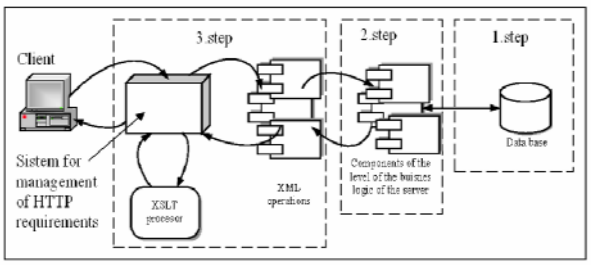


Figure 2. The steps in realization of presented exchange of information

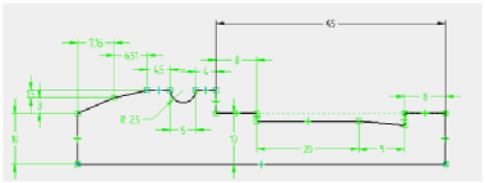
2. THE DESIGN OF MODEL FOR EXCHANGE INFORMATION ON PRODUCT

The procedure of milling road pavements is characterized with the wide range of appliance. The milling drum tools have its appliance in milling road and concrete pavements, soil stabilization, mining industry, tunneling, etc. This fact says that there is a very wide range of shapes of all milling drum tools` components. Regarding very short lifecycle of milling units` tools, one may conclude that the manufacturers of assemblies of milling drum tools are, in order to meet market demands, forced to launch extremely large assortment of these products at market in a very short terms.

A hypothetical market situation will be used for a simplified analysis of an ideal solution of informational system which would enable qualitative communication among all acters in a product lifecycle. Namely, the certain customers of road pavement mills have particular demands for tool geometry. This may be caused by the usage of the various manufacturers` point attack tools, which have different tool holders shapes, different types of bearings, fixturing etc. In this case we will take in consideration the tool holder shape.

The main activity necessary for realization of such informational system is design of a product parametric model. The model of a body of a milling drum tool is illustrated in the figure 3. The programming package for product design Solid Edge, which uses Parasolid as a geometrical kernel, was used for model designing in this work. Parasolid represents tridimensional geometrical kernel of CAD software, or “kernel” modeler, which enables fundamental functionalty in the product design procedure, that is, it provides the conditions for very effective design of associative models of high complexity level. It is based upon Boundary representation technology and upon Soild modeling, Cellular modeling, sheet metal products modeling and complex boundary modeling.

Model in the figure has been developed by the operation revolve protrusion, i.e. by profil rotation round its axis. Beside the profil, with which rotation the model is developed, the table of parameters is given, i.e.. dimension variable. Since only the tool holder is analysed here, thus only variable V1919, defining the total length of tool holder, may be important. The reliance established among this variable and the others, which define tool holder geometry, is shown in column “Formula”. The parametric model, defined in this way, enables modifying the total tool holder geometry by modification of variable V1919.



telo_noza.par:Variable Table

Unit Type | Help

	Type	Name	Value	Formule
	Dim	V2962	10.00 mm	
	Dim	V1919	45.00 mm	
	Dim	V2020	1.50 mm	
	Dim	V2779	3.00 mm	
	Dim	V2798	9.00 mm	v1919*0.2
	Dim	V2765	8.00 mm	v1919*0.178
	Dim	V2746	20.00 mm	v1919*0.45
	Dim	V2748	8.00 mm	v1919*0.178
	Dim	V2750	4.00 mm	
	Dim	V2752	2.50 mm	
	Dim	V2754	5.00 mm	
	Dim	V2950	4.50 mm	
	Dim	V2956	6.51 mm	
	Dim	V3104	7.16 mm	
	Dim	V2823	10.00 mm	
	Var	PhysicalProperties_I	0.000 kg/mm^3	
	Var	PhysicalProperties_	0.99	

Figure 3. Parametric model of milling tools and variables

Prametrically defined tool holder enables description of the tool holder by the structural object-oriented language, such as XML. In the figure 4 is given the

description of the tool holder, where variables are defined as basic elements and variables` values as attributes. At the beginning of the XML description stands the initial tag, which defines XML protocol, and immediately after it instructions important for the procedure. The defined elements are further, i.e.variables and its atributes - values. In this example the main XML advantage can be seen, and that is that it bears information on structure and information on information. Actually, XML treats this tool as an element of database, i.e. of a catalogue

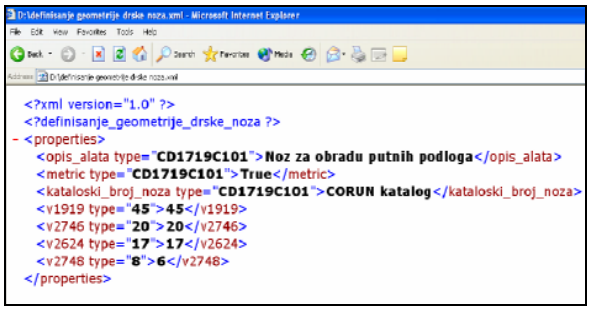


Figure 4. XML description of tool holder

As it is mentioned in the introductory chapter of this work, the customer can very simple, by fullfiling the form on the company`s site, put forward his demands upon which a product variant automatically will be generated by XSL protocol , which is integrated in application(in this case Solid Edge).

Solid Edge is a system which paid considerable attention to this way of business, therefore it has tools for automatic generation of model desriptions in HTML format and is able to meet such requirements automatically. In the figures 5 and 6 is illustrated the product model in HTML format, which enables model manipulating by the means of IPA Web Viewer program and also gives information on hierarchical structure.

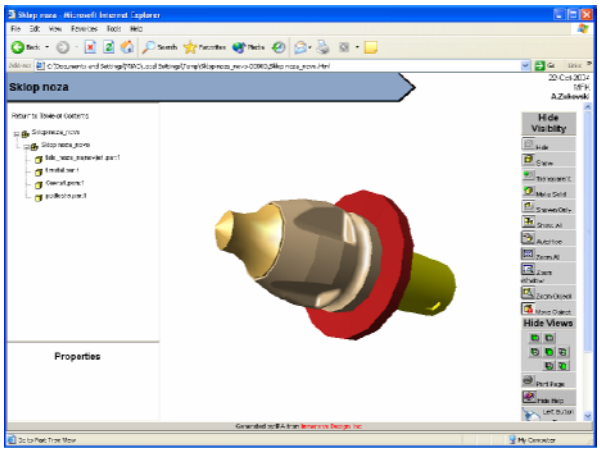


Figure 5. HTML illustration of assembly of milling drum tool

This way of exchange of information does not exist only at extreme level, manufacturer-customer, but has its usage in exchange of information between particular phases of engineering as well.

As it is mentioned, solid Edge functions upon Parasolid technology. Parasolid is represented in this work as a kernel of integration of engineering procedures.The models generated in XT, Parasolid, format are characterized with association. This means that CAM model itself will be modified by the modification of CAD model. According to the size of series ordered by customer, technological procedure of tool production will be selected. This decision-making is based upon technical-economic analysis and is liable to automatization.

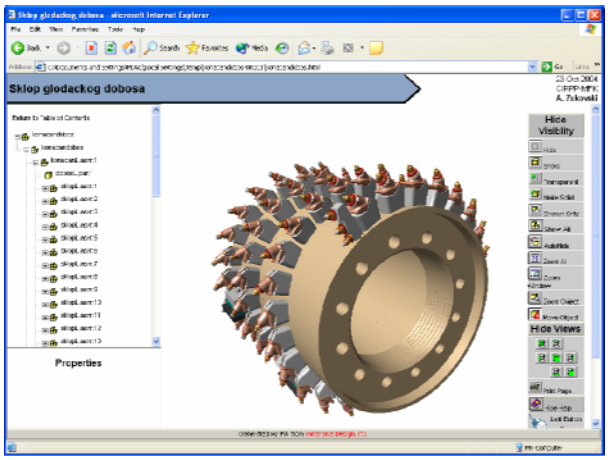


Figure 6. HTML illustration of asembly of milling drum

At design level of technological procedure, XML has its usage in exchange of information among computer-based system for technological design procedure and relational base of tools, material, machines, etc. In the figure 7. is illustrated the document which defines tools, finishing mills, and which is generated as an example of communication between tool database of ”Sandvik Coromant” and computer-based system for design of technological procedure “Edge CAM”.

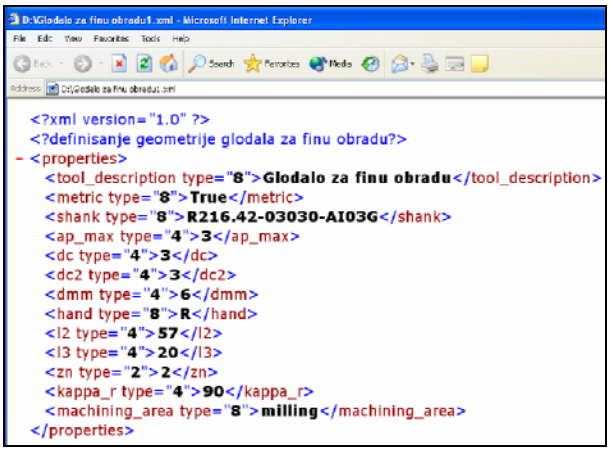


Figure 7. XML tool description

XML feature of containing information on structure and information on information is more evident in this example.

EdgeCAM can also generate all information on

technological procedure in HTML format, as in format suitable for exchange. In the figure 8. is illustrated the first page of such document which gives us the choice of job classification.

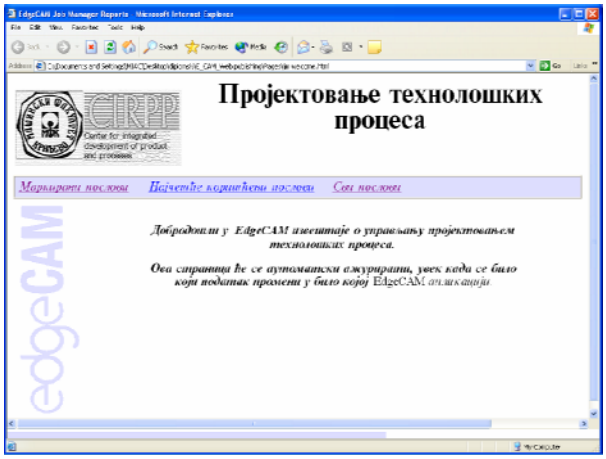
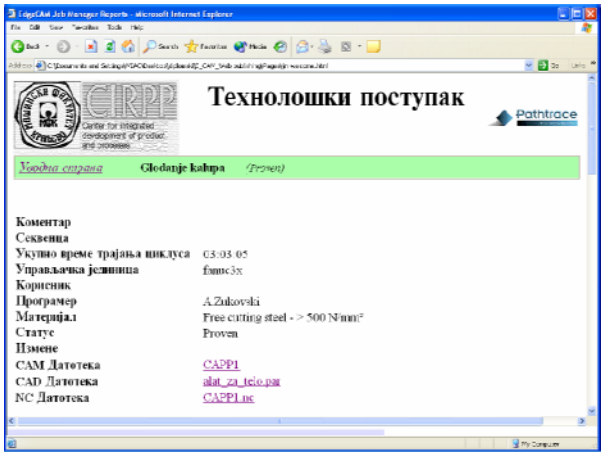


Figure 8. The first page of HTML document

The page in the figure 9 (a-c) illustrates the technological procedure of forging tool production. (9 technological procedure model manufacturing)



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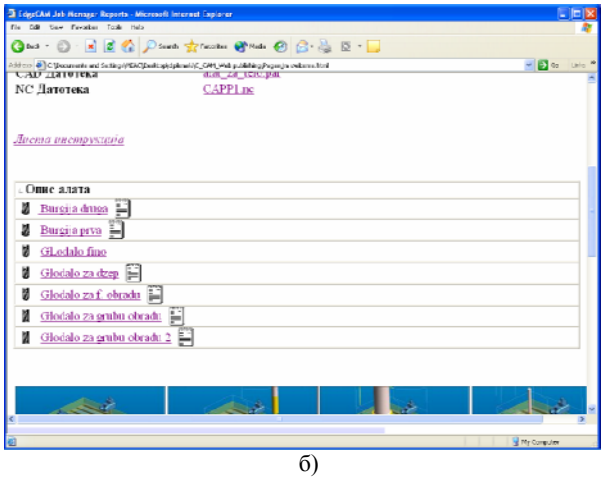

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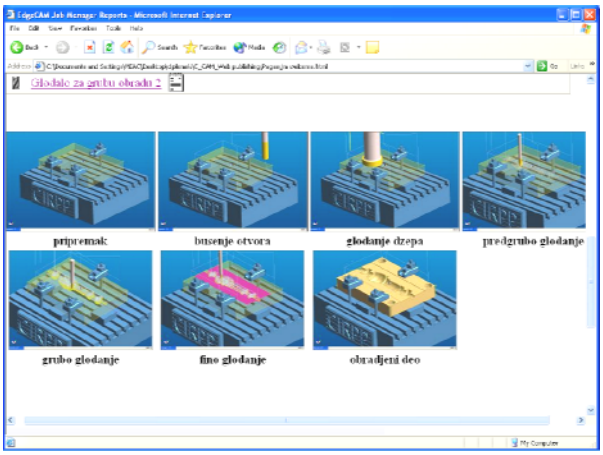

в)

Figure 9. Technological procedure model manufacturing

3. CLOSING

Modern buisnes commerce in development, production, supply and delivery of products implies high effective exchange of information between the mentioned acters with no limits in geographical locations. The role of modern Web technologies provides transmitting of product information such as geometry, assembly structure, technology, features and managing information in a very short period of time considering time zones` differences

In the example of the body of a milling drum tool for milling road infrastructural objects is shown model formation in design and exchange of necessary information related to product lifecycle.

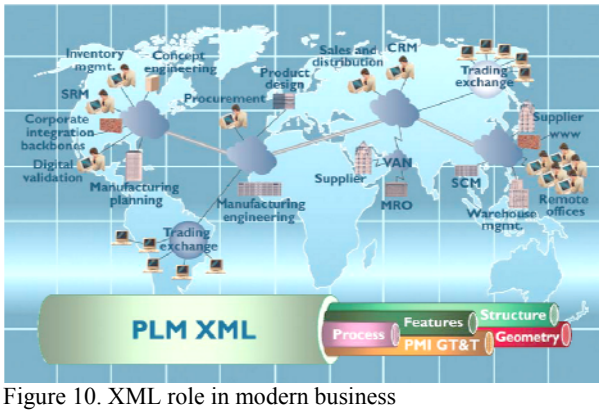

Figure 10. XML role in modern business

4. BIBLIOGRAPHY

1. Babic A, Zukovski A. and others “THE DEVELOPMENT OF PROCESSES AND MILLING TOOLS IN MILLING ROAD PAVEMENTS”, Elaborat MFKv/CIRPP 04/05 Kraljevo 2004.; 144 pages.

NONTRADITIONAL MACHINING BY ABRASIVE WATER JET CUTTING

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Abstract

New, difficult-to-machine materials and increased part complexity have resulted in the creation of new manufacturing processes, known as nontraditional manufacturing processes. Water jet cutting is one of the newest technique in non-traditional machining processes. With the water jet process, the same tooling and system can be used to cut virtyally any material, such as steel, stainless steel, high-nickel alloys and poliymer composites.
This paper presents principle of work and uses of abrasive water jet machining.

Key words: *nontraditional manufacturing processes, Abrasive Water Jet Cutting*

1. INTRODUCTION

Abrasive water jet machining is unique process that is able to cut almost all materials cost effectively and is quickly becoming a new "standard tool" in machine shops around the world. The basic technology is both simple and extremely complex. At its most basic, high pressure water flows from a pump, through plumbing and out a cutting head. It is simple to explain, operate and maintance. The process, however, incorporates extremely complex materials technology and design. Essentialy, there are two types of water jets; (a) pure water jet and (b) abrasive water jet. The first version, circa mid 1970`s, uses only water, and found early applications cutting corrugated cardoard and food items suc as cakes and candy bars. The second version, called abrasive water jet machining (AWJ), which appeared in the 1990`s introduced an abrasive sand type media into the high pressure stream to assist the cutting action, and in doing so greatly expanded the scope of what is possible. Since the AWJ version is hunderds of times more powerfol when compared to pure water jet, the range of work includes cutting stone, ceramic, glass, composites and metal.

2.0 PRINCIPLE OF WORK AND USES OF ABRASIVE WATER JET MACHINING

Abrasive water jet machining if appropriate and cost effect for a number of procedures and materials and are applied in nearly all areas of modern industry, such as automative industry, airospace industry, construction engineering, environmental technology, chemical process engineering, and industrial maintenance.

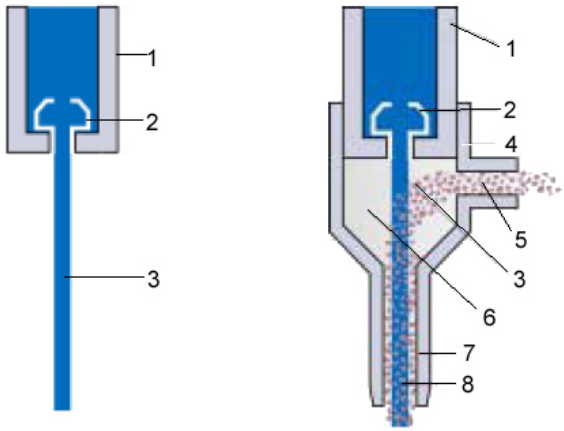
In the area of manufacturing, the water jet-technique is used for:

- material cutting
- deburring by plain water jets
- surface peening by plain water jets
- conventional machining with water-jet assistance
- cutting of difficult-to-machine materials by abrasive water jets
- milling and 3-D-shaping by abrasive water jets
- turning by abrasive water jets
- piercing and drilling by abrasive water jets
- polishing by abrasive water jets

At its basic, water flows from a pump, through plumbing, and out of a cutting head. The energy required for cutting materials is obtained by pressurizing water to high pressures and then forming a high-intensity cutting stream by focusing this water through a small orifice.

There are essential two types of water jets - pure and abrasive. With either, the water must be pressurized if it is to erode materials - and water jet is essentially an erosion process.

In pure water jet, the water stream erodes the material (Fig. 1a). In abrasive water jet, the water stream is assisted by abrasives, usually garnet, and it is the abrasives that erode the material, not the water (Fig. 1b). The abrasive stream is much more powerful than pure water jet, an is thus used to cut hard materials, such as metals.



a) Pure water jet b) Abrasive water jet

Figure 1. Cutting Head

1 Cutting head
2 Water nozzle
3 Water jet
4 Abrasive head
5 Abrasive
6 Mixing chamber
7 Abrasive nozzle
8 Abrasive water jet

Solid particles - the "abrasive" - join the water jet in the mixing chamber and are focused by the abrasive nozzle. The water jet itself has the function of accelerating the abrasive material. The extremely rapid flow rate of the water jet results in a natural vacuum situation in the abrasive head. Air and abrasive material are drawn into the mixer cavity and carried off by the water jet.

The abrasive material is subsequently accelerated by the water jet in the abrasive nozzle. For this purpose, the abrasive nozzle is in coaxial alignment to the water jet. The abrasive nozzle is approx 70 mm long, and usually with an inside diameter between 0,8 and 1,2 mm.

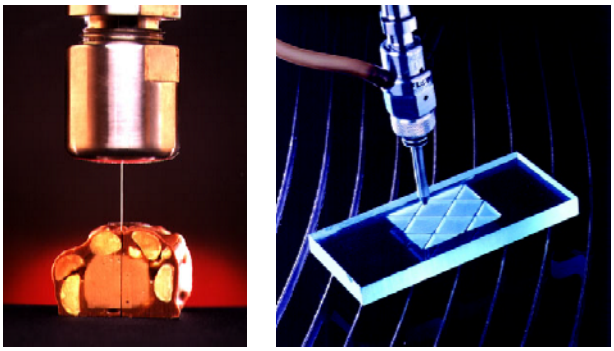


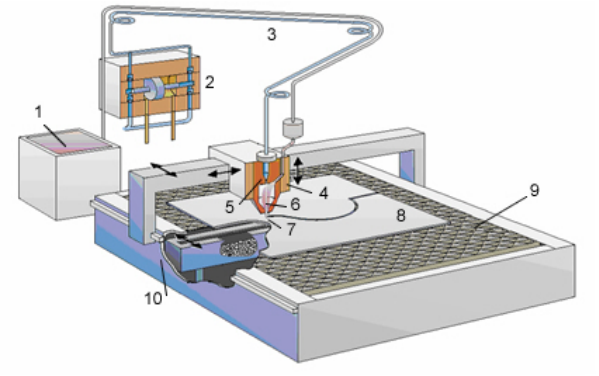
Figure 2. Pictures of pure water jet and abrasive water jet cutting heads

Figure 3 shows a chematic of the machine for cutting by an abrasive water jet and its essential components.

The high pressure pump produces the required pressure (up to 400 MPa). A high pressure supply line directs the pressurized water from the pump to the cutting head. The high pressure supply line is terminated by a nozzle at which the pressure is relieved. The result is a very thin, extremely high velocity water jet. Solid abrasive particles are added and mixed with the water jet and subsequently focused by a second nozzle - the abrasive nozzle.

The workpiece rests on the table support grids during the cutting process. The water jet penetrates the material and progressively cuts the contour relative to the motion of the cutting head.

Having penetrated the material, the residual water jet energy is absorbed by a catcher traveling synchronous to the bridge. Cutting water and sludge are transported out of the machine working area to a disposal unit.



1 Water preparation system
2 High pressure pump
3 High pressure supply line
4 Cutting head
5 Water nozzle
6 Mixing chamber
7 Abrasive nozzle
8 Workpiece
9 Table
10 Catcher

Figure 3. Machine for abrasive water jet cutting

The pump is the heart of the water jet system. The pump pressurizes the water and delivers it continuously so that a cutting head can then turn that pressurized water into a supersonic water jet stream. Two types of pump can be used for water jet applications - an intensifier based pump and a direct drive based pump.

Direct drive pump

For low to intermediate pressures up to 280 MPa direct pressurization the use of triplex positive displacement pumps is adequate. These deliver water by the action of oscillating pistons, which are directly coupled to a crankshaft rotating at a constant speed. Thus the delivered flow of water is constant in time. Figure 4 is a schematic of a direct drive pump system.

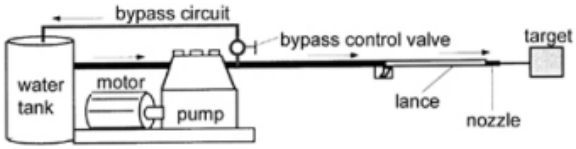


Figure 4. Schematic of pump and water supply system

These pumps are gaining acceptance in the water jet industry due to their simplicity. Though direct drive pumps are used in some industrial applications, the vast majority of all ultrahigh pressure pumps in the water jet world today are intensifier based.

Intensifier based pumps

With high pressures, direct drive pump is less reliable and additional components must be incorporated to maintain a constant volume at a constant high pressure. One such method is the use of an intensifier (Figure 5). An intensifier usually consists of two cylinders with different inner diameters. The piston with

the largest diameter is driven by a low-pressure hydraulic system (normally 5 to 35 MPa). The pressure in the other cylinder is higher due to the difference in diameter and the radio of the pressures varies directly as the ratios of cross sectional areas of the two cylinders making up the intensifier. These rations are typically of the order of 1:10 to 1:25. The resulting magnification in pressure results in values up to 400 MPa. To operate in a quasicontinuous mode, two or more intensifiers are used together.

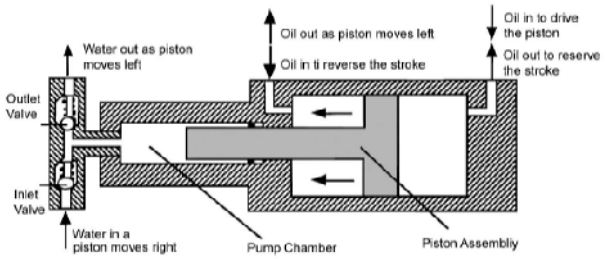


Figure 5. Intensifier

Intensifier based pumps are mostly plunger pumps. A solid plunger is pushed into a closed chamber, raising the pressure and expelling the pumped fluid through an outlet check valve. Then, the direction of the plunger motion is reversed, and low-pressure fluid fills the chamber through an inlet check valve. The continuously reciprocating plunger provides the pumping action (Figure 6).

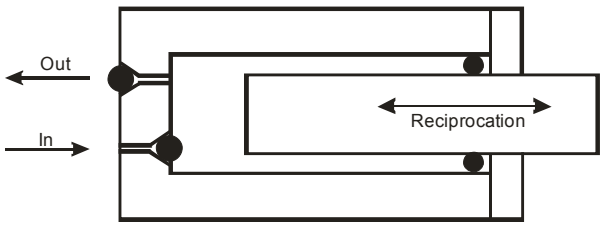


Figure 6. Pumping chamber

At 380 MPa, water is about 12 percent compressible. That means that the plunger must move enough to fill 12 percent of the chamber volume before the pressure reaches 380 MPa. At that point the outlet check valve can open against the pressure already in the output line. Then, at the end do the stroke, when the plunger reverses and the outlet check valve closes, any water trapped in the cylinder continues to expand and push on the plunger until the plunger has moved far enough to drop the pressure on the inlet check valve. The energy put into the plunger motion by this expanding trapped water can be recovered or not depending upon the drive type.

Because of the compressibility of water by high pressure, comes to pressure fluctuations and this in turn causes inaccuracies in the water jet/abrasive eater jet machining operations. One method to address this problem of pressure fluctuations is to use double acting intensifier and to include an accumulator design which is shown in Figure 7.

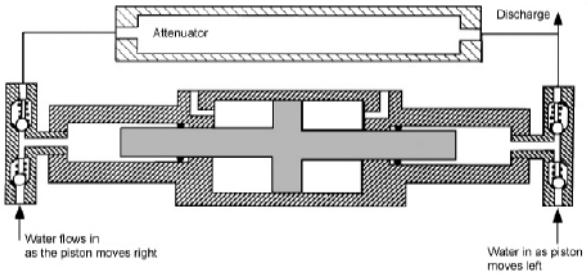


Figure 7. Use of an accumulator with a double acting intensifier

In a double acting intensifier design the units are directly connected and work alternately; while one intensifier unit delivers pressurized water to the system the other unit is refilled. The accumulator (this is also known as an attenuator) stores a volume of water at an elevated pressure which it will release into the system as a decrease in pump pressure is sensed. This then reduces the variations in system pressure.

3.0 ADVANTAGES OF ABRASIVE WATER JET CUTTING

Abrasive water jet cutting offers many advanteges over conventional cutting methods. They include:

- cold cutting - no heat-afected zones, no hardening
- cuts virtually any materijal
- minimal ficturing required
- environmentally friendly
- reduces dust and hazardous gases
- provides stress-free cutting
- saves raw materials - small cutting kerf width and nesting capabilities

One of wate jets`s biggest advantages is its cold-cutting quality. This allows materials to be cut that would be burned, melted, or cracked by other cutting methods. Another advantage is its ability to cut reflective materials, uneven survaces, and stacked layers of different materials. High cutting accuracy is achived withoud leaving any frayed edges or burrs. Therefore, edge quality is such that in many cases the need for secondary finishing processes is eliminated.

In comparation with other non-conventional manufacturing processes abrasive water jet cutting is slower than laser or plasma. But if you look at how fast you can get a finished part and at what cost, the water jet typically comes out ahead, thanks to no secondary operations are required - saving both time and money.

3. CONCLUSIONS

In the last few years, the abrasive watre jet machining has shown a rapid development due to its remarkable advantages and its capability to extend to new fields of application. As their advantage has become clear, so water-jetting equipment has been developed, used and water jets have become, in several industries, the accepted method for solving a problem.

Predictive control enables the machining systems incorporating water jets to match of better the accuracy and quality of the competing technologies. Some previously impossible tasks can now be carried out cost-effectively opening up the market place for a whole new range of new manufacturing materials. This machining technology, however, compliments other technologies, such as milling, laser, EDM, plasma, as well as a host of other traditional and non-traditional processes used in manufacturing industry.

LITERATURE

[1] Hoogstrate A.M., van Luttervelt A.M.;Opportunitirs in Abrasive Water-Jet Machining, *Annals of the CIRP Vol. 46/2/1997.*

[2] Brandt, C., Louis, H., ...: Schneiden mit Wasserabrasivstrahlen-Verfahren, Anwendungen, Entwicklungs-potential; *Internationale Schnaidtechnsche Tagung ICCT, 1997.*

[3] Louis, H.: Aktueler Stand der Wasserstrahltechnik; *IIR Seminar Laser-Wasserstrahltechnik, 2000.*

[4] Janković, P., Radovanović, M., Vicovac, N.: High-pressure pump - "Heart" of the machine for contour cutting by an abrasive water jet, *29. HIPNEF 2004 sa međunarodnim učešćem, 19. – 21. maj 2004, Vrnjačka Banja*

[5] Janković, P., Radovanović, M., Vicovac, N.: Characteristics and use of water jet machining, *4. medjunarodna konferencija RaDMI 2004, septembar 2004,Zlatibor*

[6] OMAX JetMachining - web page

[7] Wasterjet Technology Inc. - web page

DRILL STIFFNESS ANALYSIS

Vasić Ž., Kalajdžić M.

Summary

This paper contains results of the twist drill stiffness analysis which significantly influence the drilling process dynamics. The statements for the thrust and torsional stiffness of the twist drill, as helical body, have been obtained in the function of the drill diameter and length as a result of the Finite Element Method Analysis (FEM analysis). The paper also analyzes the impact of the of the standard twist drill helix angle on the stiffness…

1. INTRODUCTION

Twist drill is an interesting subject for research because of its complex geometry and its impact on the drilling process. Twist drill point geometry is defined by a characteristic flute surface and flank surface obtained by the respective twist drill point grinding. The flute surface consists of the rake surface formed by helical movement of the main cutting edge along the drill axis and rear part surface designed on the basis of optimum chip evacuation from the cutting zone and drill stiffness. The cutting edge is obtained at the inrtersection of the rake and flank surfaces and it is characterized by of the flank and rake angles variation which cannot be disregarded in a serious analysis of the drilling process. Mathematical model of the conical twist drill and analysis of the geometrical variation along the cutting edge is shown in detail in the paper [2] Flank and rake angle variation, with variation of the cutting velocity along the cutting edge points out to a great influence of the twist drill point geometry to the cutting forces i.e. chip formation mechanism in the cutting zone. The twist drill point flute surface required for chip evacuation and cutting edge formation significantly decreases the stiffness of the tool-twist drill which affects the machining system characteristic-stiffness. The impact of the twist drill stiffness on the machining system stiffness points out to the requirement to find adequate analytical statements which would be used as basis for obtaining approximate values of the respective stiffness. Application of computers enables simulation of the twist drill deformation based on the finite element method without any need for adaptation of the existing analytical statements of the stiffness of the twist drill helical body geometry. The analysis does not include the impact of the twist drill shank since the method of the twist drill clamping in the main spindle ensures rigid connection with the main spindle. Finite element method analysis of the stiffness provides a more realistic impression about the twist drill cutting edge and drill body as a consequence of the of the approximately real cutting force. The paper represents a finite element method analysis of the twist drill thrust and torsional stiffness in the function of diameter, helix angle and length

2. DISCRETE TWIST DRILL MODEL GENERATING

Twist drill static analysis has been performed for the conical twist drill that is most commonly met in practice, whose the detailed mathematical model is shown in the paper [2], On the basis of this mathematical model, the CAD model of the conical twist drill, as shown in the figure 1a., has been formed in Pro/Engineer which was used for the twist drill deformation finite element method analysis in the FEM software. Due to the twist drill complex geometry, the mesh is automatically generated by application of the existing preprocessor in Pro/Mechanic having the possibility of manual control of the finite element parameters in the form of curved tetrahedron to which the twist drill geometry is approximated and which the accuracy of the obtained results depends on.

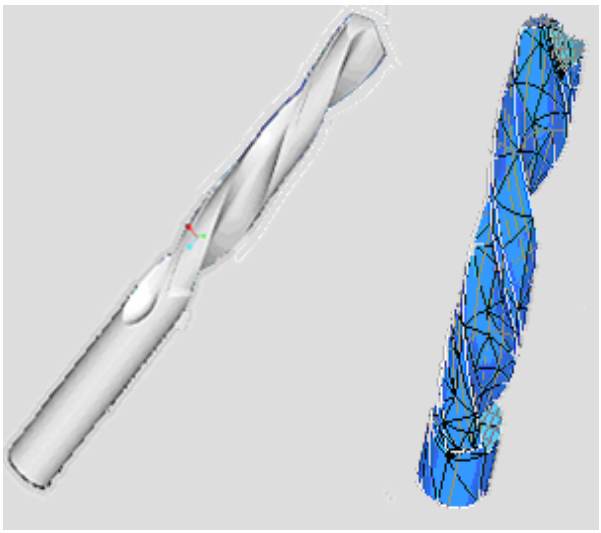


Fig 1. CAD and twist drill model with mesh

Application of the curved 3D finite elements ensures better approximation of a very complex twist drill geometry. The twist drill model with the generated mesh is shown in the figure 1b. Number of the finite elements to which the twist drill geometry has been approximated depends on the twist drill dimensions (diameter and length) and ranges between 100 and 1000. Apart from the twist drill model with mesh, the loads and boundary conditions should be defined for the purpose of conducting the finite element method analysis. In this analysis, we observe the twist drill as a console seized above the twist body so that only the drill body so that stiffness is influenced only by the drill body (twist drill shank stiffness is not taken into consideration).It is necessary to make an analysis of the cutting forces at drilling in order to follow up the twist drill deformation the on the basis of the real loads generated in the cutting process i.e. in order to define approximate real loads on a twist drill discrete model used for finite element method simulation of deformation and defining of the respective stiffnesses in relation to it.

The twist drill load is defined in accordance with the cutting forces formed on the twist drill point. The resultant cutting force on the cutting edge in the drilling process can be divided into three components: F_1- main cutting force which is orthogonal to the position vector of the observed point in which the resultant cutting forces act, F_2-radial force which is orthogonal to the machined surface F_3-feed force concurrent with the drill axis. The cutting forces are shown in the figure 1. The main cutting forces form the torsion moment called drilling torque, the radial forces are of the same intensity and of the opposite direction and, in the ideal case of drilling, they nullify one another while the feed forces are added from the cutting edges forming drilling thrust force. Consequently, the twist drill is under load of the torsion moment M and drilling thrust force F_3 the approximate values of which can be obtained by application of the statements given in [3].

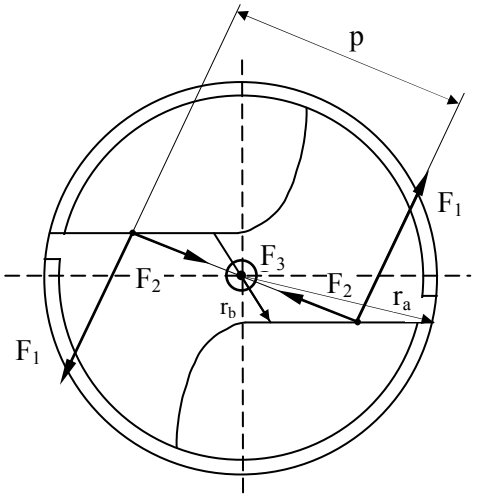


Figure 2. Cutting forces at drilling

Application of the point load shown in the figure 1. does not express the twist drill deformation in an adequate way due to large local deformations in the observed point and variable stiffness and cutting forces of the twist drill along the cutting edge although the results obtained in this way can be applied for the purpose of obtaining informative deformation values. Application of the continually distributed loads along the cutting edge represents a more realistic case but there is no possibility of accurate determination of this distribution. The change of geometry described in the paper [2] and cutting velocity along the twist drill cutting edge points out to the variation of the cutting forces coefficient in the function of the observed point on the twist drill cutting edge. It is possible to achieve approximately realistic distribution of the cutting force by means of the estimation of the cutting force coefficient for each point on the cutting edge. However, due to the fact that the chisel edge geometry and material indentation mechanism on the chisel edge require additional experimental tests for the purpose of determination of the resultant cutting force distribution on the chisel edge, the load distribution acquired on the basis of the previous research in the field of the drilling process, shown for the tangent and drilling thrust force in the figure 2, has been applied in this paper. According to some experiments, the cutting force acting on the cutting chisel equals 15% of the resultant cutting force which appears on the cutting edge while the torsion moment can be disregarded due to a small value of the drill chisel width. Due to the non-existence of the adequate mathematical model for description of the cutting in the field of the cutting chisel, the following assumptions have been accepted: a) the torsion moment on the cutting chisel can be disregarded, b) the thrust force along the main cutting edge is uniformly continuoally distributed and its value is equal to 50% of the total thrust force in the drilling process. It can be concluded, from the figure 3., that the drilling torque is replaced by tangent force-main cutting force which is uniformly continually distributed along the cutting edge where the tangent force coefficient per a unit of length is computed on the basis of the following statement:

$$F_{tl} = \frac{Ftr}{l_{gs}} = \frac{M}{2\int_{ra}^{rb} r(\xi)\cdot d\xi} \qquad (1)$$

where: F_{tr}-tangent-main cutting force, l_{gs}- cutting edge length, M-drilling torque, $r(\xi)$-cutting edge point position vector.

The drilling thrust force on the cutting edge equals 25% of the resultant drilling thrust force and its distribution along the cutting edge has a shape of a continual distribution triangle with zero on the circumference and maximum value at the intersection of the cutting and chisel edges as shown in the figure 3. The model of the twist drill loads, on the basis of

which the thrust stiffness and torsional stiffness are computed by means of the finite element method, is defined in accordance with the previous analysis.
The FEM model of the twist drill with tangent loads (the forces which replace the drilling force) is shown in the figure 3a. and the model with thrust loads in the figure 3b., where the previously defined distribution of loads along the cutting edge can be noticed.

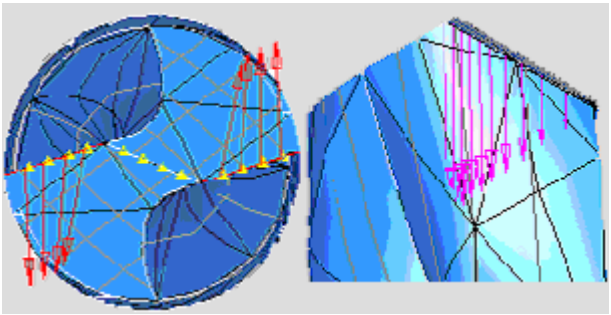
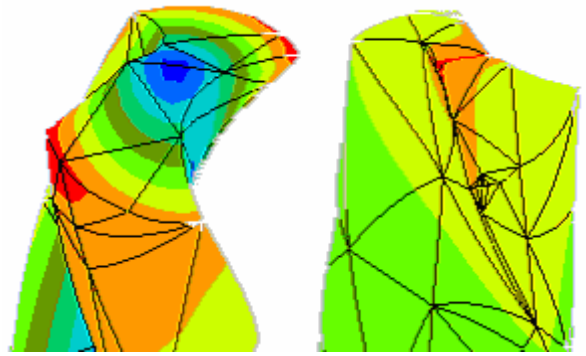


Figure 3. FEM model of the twist drill with a) tangent, b) thrust loads (cutting force)

The calculation was performed using the p-adaptive finite element refinement the theoretical bases of which were given in [5]. The results obtained by the finite element method analysis have convergence below 10% which is a high rate for such a complex geometry. The twist drill deformations resulting from the thrust loads are shown in the figure 4a and those resulting from the torsion moment are shown in the figure 4b.



a) b)

Figure 4. Ffinite element method analysis of the twist drill stiffness a) deformation of the twist drill loaded by thrust force, b) deformations of the twist drill loaded by torsion moment.

Displacement taken as adequate for thrust stiffness calculation is obtained as average displacement in 4 points on the cutting edge and the point of intersection of the twist drill longitudinal axis and chisel edge. The helix torsion for calculation of the torsional stiffness is obtained as average helix angle for 4 points on the cutting edge. These helix angels are obtained indirectly by dividing the displacements in the arc direction with the respective intensity of position vectors of the observed point on the cutting edge. In this way, an attempt to eliminate the local deformations on the twist drill cutting edge was made.

3. TWIST DRILL TORSIONAL AND THRUST STIFNESS

Twist drill torsional stiffness is defined as a ratio between the drilling torque and the respective average helix angle as defined in the chapter 2, which can be expressed by the following statement:

$$c_t = \frac{M}{\theta_{sr}} \quad [Nmm/rad] \qquad (2)$$

where: $\theta_{sr} = \frac{1}{4}\sum_{i=1}^{n}\frac{s_i}{r(z_i)}$,

s_i-displacement in the arc direction of the point on the cutting lip with the radial distance between the drill center point on the cutting lip

The twist drill thrust stiffness is defined as a ratio between the thrust force and the respective average decrease of length, i.e. displacement of the drill point in the axial direction on the basis of the following statement:

$$c_a = \frac{F_3}{z_{sr}} \quad [N/mm] \qquad (3)$$

Analysis of the twist drill torsional and thrust stiffness has been performed for standard type N twist drills (helix angle 30°) within the range of diameter 5-15 mm and length 23-144 mm. The statements for the respective stiffness have been obtained by means of the regressive analysis and have the following form:

$$c_t = 0.84262 \cdot \lambda^{0.999} \cdot D^{3,0112} \; [kNmm/rad] \qquad (4)$$

$$c_a = 31{,}365 \cdot \lambda^{1.0537} \cdot D^{1,0938} \; [kN/mm] \qquad (5)$$

where: D-drill diameter, λ=D/l-drill non-dimensional parameter , l-drill body length

The statements for thrust stiffness and full beam cross-section diameter torsional stiffness have been given for the purpose of comparison of the twist drill and beam stiffness.

$$c_{tš} = \frac{G \cdot I_o}{l} = 7{,}74543 \cdot \lambda \cdot D^3 \; [kNmm/rad] \qquad (6)$$

$$c_{aš} = \frac{A \cdot E}{l} = 157{,}001 \cdot \lambda \cdot D \; [kN/mm] \qquad (7)$$

Analysis of the twist drill and beam stiffness shows that the twist drill thrust stiffness equals 20% and tosional stiffness is 10% of the respective stiffness of the full circular cross section beam, which points out to a great impact of the flute surface on the twist drill stiffness and drilling process rate.

The results for thrust stiffness and torsional stiffness obtained by finite element method for the diameters

D=5,7,9,11,13, and 15 mm and various lengths of the drill body are shown in the figure 5. The results obtained by the statements (7) and (8) are shown in parallel in the figure 5.

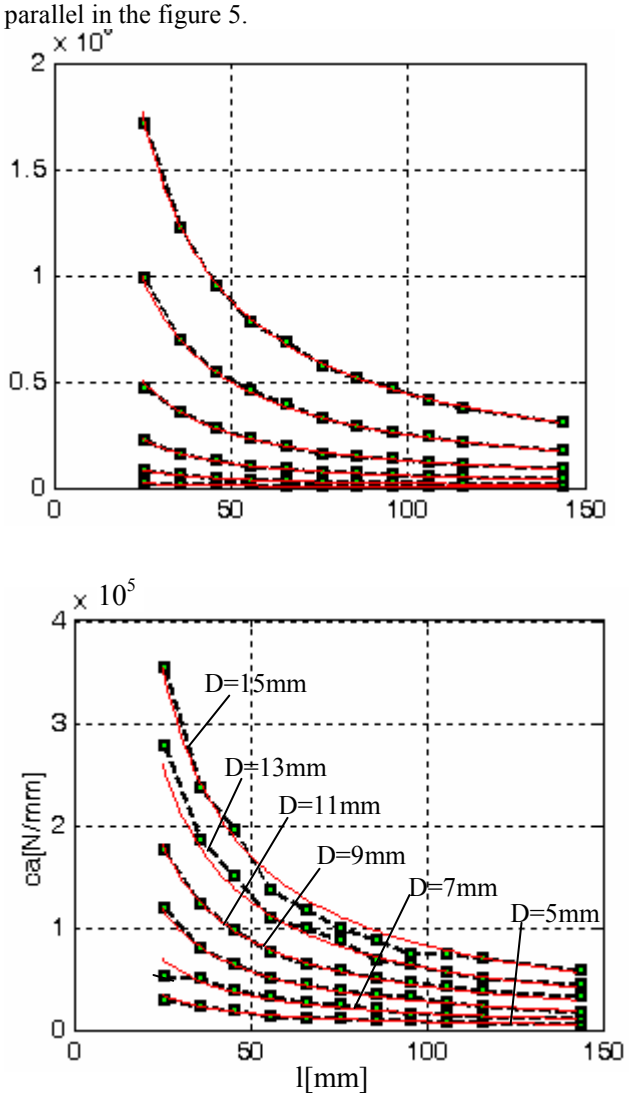


Figure 5. Twist drill stiffness in the function of the diameter and drill body length: a)torsional stiffness b) thrust stiffness

Analysis of the standard twist drill thrust and torsional stiffness shows that the twist drill thrust stiffness increases and torsional stiffness decreases with the decrease of the helix angle. This analysis refers to the type M twist drills (for soft materials – helix angle 40°) and type T drills (for hard materials –helix angle 13°). Figure 6a shows the torsional stiffness variation and figure 6b thrust stiffness variation for standard short twist drills in the function of the diameter and helix angle β i.e drill type.

4. CONCLUSION

Application of the analytical model for calculation of the stiffness of the twist drill, as a drill body, enables identification of the twist drill stiffness without any experimental tests and the finite element method simulation. The approximate values of the twist drill thrust and torsional stiffness obtained on the basis of the derived statements are of help in the drilling process studies.

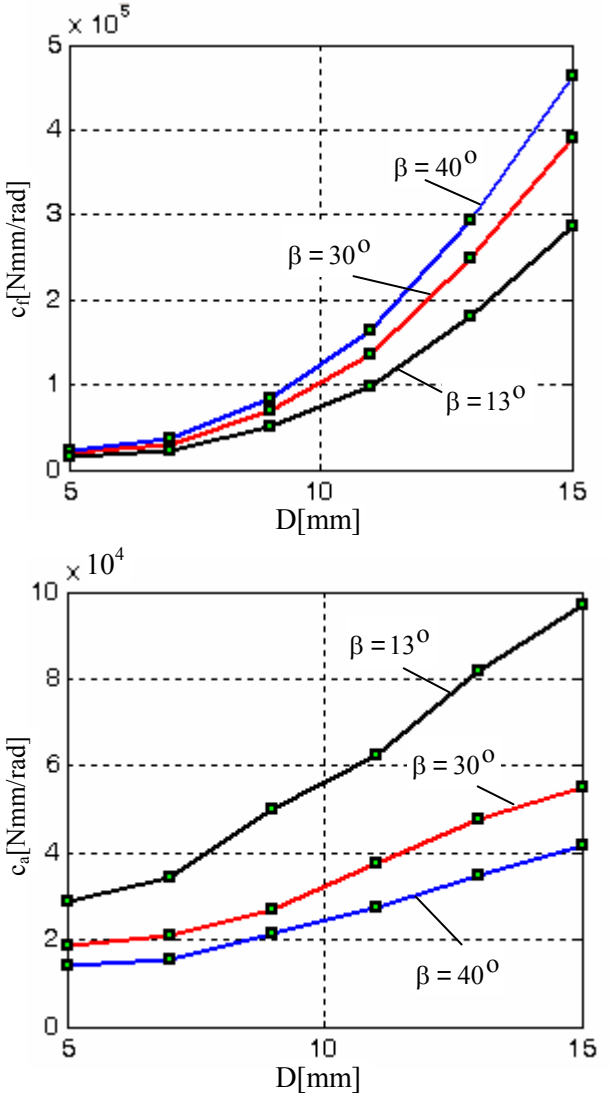


Figure 6. Twist drill stiffness in the function of the helix angle: a) torsional stiffness b) thrust stiffness

5. REFERENCES

[1]. Altintas Y., "Manufacturing automation", Cambridge University Press, UK, First Edition, 2000

[2]. Vasić Ž., Kalajdžić M., "Analiza geometrije reznog dela zavojne burgije duž glavnog sečiva", 30 Jupiter konferencija, Zlatibor, 2005, pp 3.51-3.54

[3]. Kalajdžić M., "Tehnologija mašinogradnje", VIII izdanje, Mašinski fakultet, Beograd, 2002

[4]. Kalajdžić M., "Tehnologija obrade rezanjem", Priručnik, IV izdanje, Mašinski fakultet, Beograd, 2004

[5]. Zienkiewicz O. C., Taylor R.L., "The Finite Element Method", Fourth Edition, McGraw-Hill, 2000

CONTRIBUTION TO VIRTUAL MANUFACTURING MODELLING

Miroslav Pilipović[1], Dejan Vučković[2], Žarko Spasić[3]

***Abstract**: Virtual manufacturing as concept applied in the design of advanced manufacturing systems, enables realization of manufacturing processes in synthetic computer environment in the same way as under real conditions. The paper describes the concept and architecture of the Control-Centered virtual manufacturing environment defined by integration of different tools for products, manufacturing processes and manufacturing resources modelling. The applications of developed concepts and environment for virtual manufacturing system modelling are also given with an example.*

1. INTRODUCTION

The globalization of the market of today requires the manufacture of increasingly complex products, with a great range of project design variants to adjust with and meet the specific needs of the end buyer. This imposes the need for as short as possible manufacturing cycle, as well as the distribution of design, development and manufacturing tasks to several geographically distant sites. Simultaneous decreasing or complete removal of inter-state barriers enables the existence and growth of efficient and innovative, i.e., agile companies. The designers of advanced products and workshops, as well as the management of business and production systems, have therefore to pass decisions each day in order to find the best balance between the product quality and price, deadlines and production equipment performance. Advanced manufacturing systems, however, require an increasing use of computer for accomplishing of a large number of activities for computer information processing or process control. Such intensive changes in the field of manufacturing and computer technologies demand continuous development of existing concepts and the creation of new concepts. The concept of computer integrated manufacturing - CIM integrates all computerized fields in manufacturing systems. In the design field a new concept is being defined - Virtual Manufacturing Systems (VMS).

2. VIRTUAL MANUFACTURING

According to the professional literature, virtual manufacturing (VM) system may be defined in several ways. According to Onosato [1] and Iwata [2], this concept executes and estimates manufacturing processes in computers, without the use of real facilities. Computer system entitled as "virtual and informational system" simulates real and information system, and generates control commands for the real and physical system. The same authors extend and define this concept as the aggregation of various computer hardware and software, requiring wide range of modeling and simulation tasks. Based on an analysis dealing with the information dependence between the tasks, Iwata [2, 3] proposes that VM system architecture should be defined with seven types of the following activities: device model preparation, service development, virtual shop floor definition, operation definition, product handling, virtual shop simulation and simulation interface. The core idea of the other concept given by Kimura [4] is that a parallel to the real world of CIM enterprise is a modelled virtual world comprised from product model, virtual prototype model, manufacturing resource model and manufacturing environment model. According to Wiendahl and Scholtissek [5], this model of reality (engineering and business activities) creates the test field for experiments about the influence of production design on the production itself, as well as on planning of supported operations and tests of new methods in production management. Lin [6] defines the VM system as an integrated, synthetic manufacturing environment, whose purpose is to enhance all levels of decision and control comprising design-centered VM, production-centered VM and control-centered VM.

3. CONTROL-CENTERED VIRTUAL MANUFACTURING

Three paradigms defining specific view of the VM, were proposed at the "Virtual Manufacturing User Workshop" held in Dayton, Ohio on 12-13 July 1994 and published in the "Technical Report, Compiled and Edited by Lawrence Associates Inc." (Obtained from the www address http://www.isr.umd.edu). These three paradigms, Design-Centered VM, Production-Centered

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VM and Control-Centered VM, have been analyzed in more detail by other authors as well, and particularly in [6]. Design-Centered VM uses manufacturing-based simulation to optimize the design of products and processes for specific manufacturing goals such as design for assembly, quality, lean operations, and/or flexibility. Production-Centered VM provides an environment for generation of process plans, production plans and resource requirement planning. Simulation is used to allow inexpensive, fast evaluation of many processing alternatives. Control-Centered VM provides information for optimizing manufacturing processes and improving manufacturing systems with the use in simulation of control models and actual processes as well.

Taking into consideration the above-mentioned paradigms with further development of the previously defined model of virtual manufacture for extended CIM enterprise, the authors of this paper have built the concept and the architecture of control-centered VM, as described in [7].

The basic concept of this model illustrated in Figure 1 was made with IDEF0 methodology for functional modeling.

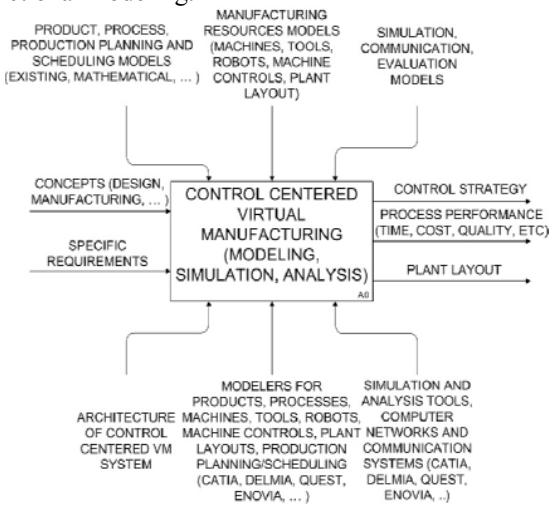

Figure 1. Control-centered VM concept

The main inputs are product and process models. For the established production planning/scheduling, model different variants of shopfloor and machine control models may be defined and modeled, so that control optimization elements (control strategy, process performances and possible shopfloor layout) may be obtained through distributed simulation process.

For this model, in agreement with defined concept, detailed architecture of the Control-Centered virtual manufacturing system is given in [9].

It is possible to single out in the system the subsystems for modelling of virtual manufacturing system components (parts, processes, equipment and control resources), the distributed simulation controller, computer resources for the creation of virtual environment - simulation, as well as the system of joint data/knowledge base.

4. VIRTUAL ENVIRONMENT FOR ADVANCED MANUFACTURING

Based on defined concept and the architecture of Control-Centered Virtual Manufacturing Systems, the detailed functional model of virtual manufacturing systems is developed. The IDEF0 methodology for functional modeling and UML methodology for object oriented are used in analysis and design of the VM system [9, 10]. According to the basic functional concept (Figure 1), activities and life cycle of the virtual manufacturing are modeled [10]. Four stages are defined: product design, manufacturing preparation, manufacturing resources modeling, simulation and analysis.

Main supports of the presented concept are modelers for the system components. The "big four" CAD/CAM/CAE/PDM vendors: Dassault Systems/IBM Corp., Parametric Technology Corp. (PTC), SDRC, and Unigraphics Solutions Inc.--all claim to offer "design-through-manufacturing solutions." As such, all have ties into the virtual manufacturing world. According to that, the modeling of parts and processes in this stage of the system development is achieved with the use of standard advanced CAD/CAM/CAE systems (Catia [11]), with models based on STEP and other data files types. For further developing of the system, other software tools will be used (Delmia, Enovia, Quest, etc.).

4.1. Products Modeling for Virtual Manufacturing

The modeling of virtual products is the first phase in realization of the virtual manufacturing system. Within years, long cooperation between HC "Petar Drapsin" and the Faculty of Mechanical Engineering in Belgrade a part of the research has been devoted to the development and introduction of advanced technologies in the manufacture of cylinder assemblies [8]. According to the fact that virtual manufacturing has its roots in the automotive industry, together with the CIM the new approach to the design field is defined through the virtual manufacturing system - VMS concept for advanced manufacturing of cylinder assemblies.

Without entering into all detail about the design, mathematical models and CAD/CAM modeling of the piston, on the Figure 2 CATIA 3D CAD model of the piston example is given. The presented models are generated in internal CATIA file format. For the defined concept of the virtual manufacturing and using of Iternet/Intranet network, VRML[1] file for presented CAD models are generated also.

The manufacturing preparation is the second phase in the virtual manufacturing system modeling. It contain: manufacturing processes modeling and production planning and scheduling modeling. In this paper manufactuing processes modeling examples are given using CATIA modul for NC manufacturing/programming. The example of process

[1] VRML - Virtual Reality Modeling Language

planning for the piston manufacturing is shown on Figure 3 (simulation of turning on CNC lathe with tool paths presentation).

Figure 2. Piston (CATIA 3D) models

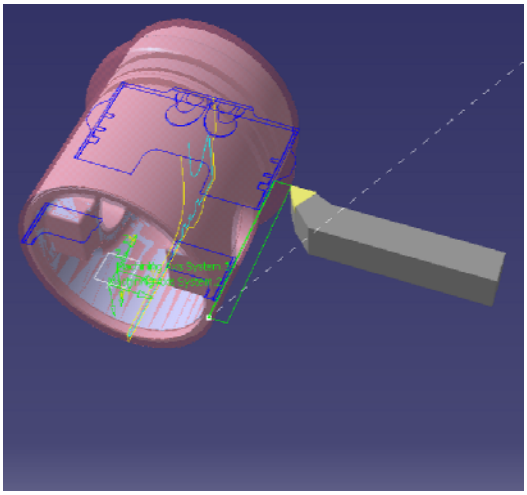

Figure 3. Piston turning simulation and tool paths

For the designed process plan, tools and cutting data selection are realised in two stage: tool selection from CATIA catalogues with the basic data for simulations and real tools and cutting data selection from the tool manufacturer catalogues. Example of the turning tool selection from the Seco catalogues are shown on the Figure 4 [12]. For the final modeling of tools and other equipment, real models are used when even it is possible.

4.3 Manufacturing Resources Modeling

The modeling of the manufacturing resources is of special significance for the created Control-Centered virtual manufacturing. The concepts of advanced manufacture such as flexible automation, computer integrated manufacture, holonic manufacturing systems, agile manufacturing systems, intelligent manufacturing systems and others represent development steps of 21st century factories - flexible, fully automated and, according to some, intelligent factories without men. All these concepts are based on advanced manufacturing programmable equipment such as CNC machine tools, industrial robots and other automated systems. The advanced programmable equipment uses specialized-purpose-oriented control systems (CNC control units, robot controllers, cell controllers, programmable controllers) and general-purpose control systems based on industrial or personal computers. According to that, manufacturing resources modeling includes modeling of physical resources (machines, robots, conveyers, tools and attachments), modeling of control resources and modeling of plant layout. The example of the machine tools modeling using CATIA modules (Mechanical design, Equipment and systems, etc.) is shown on the Figure 5.

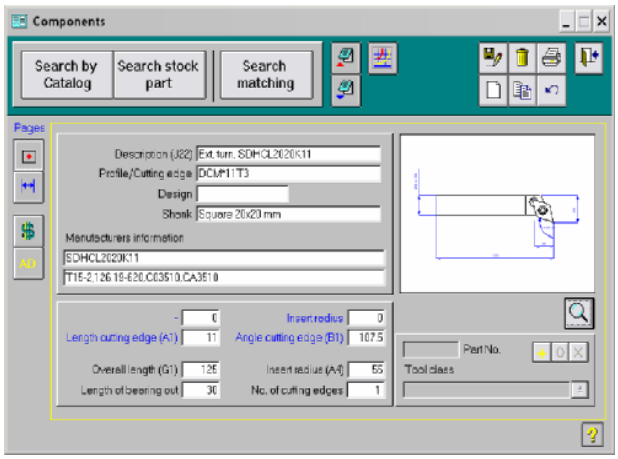

Figure 4. Tool selection example

Complying with the above requirements and in the view of current projects carried out at the Chair for Production Engineering at the Faculty of Mechanical Engineering in Belgrade, that involve implementation of programmable controllers, the authors have decided to construct development environment for the modeling of virtual programmable logic controllers (Virtual Control System Modeler) [9].

The test example of the application of the developed virtual programmable logic controller in the task of the control of pick-and-place robot is illustrated in Figure 6.

5. CONCLUSIONS

In this paper, the concept and the architecture of Control-Centered virtual manufacturing environment are defined. The developed concept of the virtual manufacturing system has four stages: the products modeling, manufacturing processes modeling, manufacturing resources modeling, simulation, and analysis. The defined concept is modeled in detail using

IDEF0 methodologies. The test example of the designed environment application for the cylinder assemblies' virtual manufacturing system modeling is given.

The development of the described virtual manufacturing environment architecture will be further directed towards open system architecture for control in advanced manufacturing automation. The plans are also made to expand developed virtual manufacturing with modules for computer education in the field of automated processes and systems.

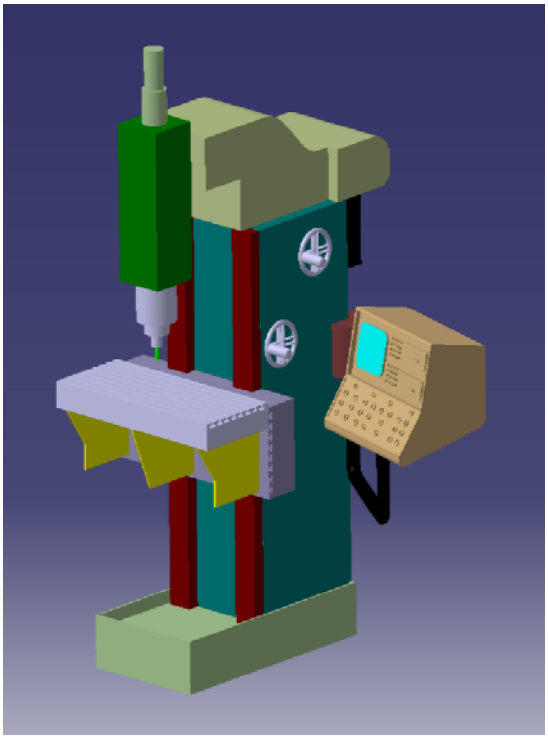

Figure 5. CNC machine tools modeling (milling machine CATIA 3D model)

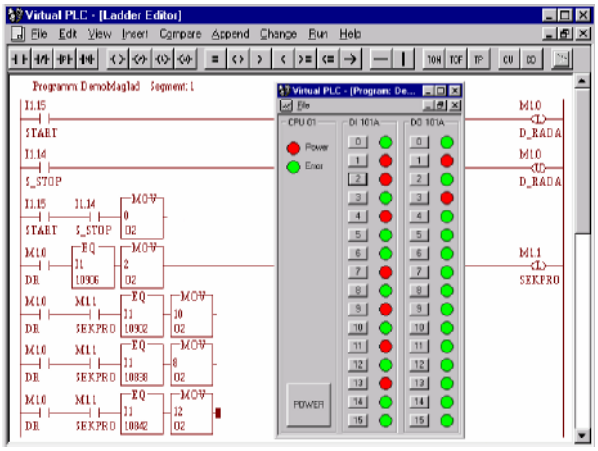

Figure 6. Test example of the virtual PLC

6. REFERENCES

1. M. Onosato, K. Iwata, Development of a Virtual Manufacturing System by Integrating Product Models and Factory Models, *Annals of the CIRP,* 42/1, 475-478, 1993.
2. K. Iwata, M. Onosato, K. Teramoto and S. Osaki, A Modelling and Simulation Architecture for Virtual Manufacturing Systems, *Annals of the CIRP,* 44/1, 399-402, 1995.
3. K. Iwata, M. Onosato, K. Teramoto and S. Osaki, Virtual Manufacturing Systems for Integrating Manufacturing Resources And Activities, *Annals of the CIRP*, 46/1, 335-338, 1997.
4. F. Kimura, Product and Process Modelling as a Kernel for Virtual Manufacturing Environment, *Annals of the CIRP,* 42/1, 147-150, 1993
5. H.-P. Wiendahl, P. Scholtissek, Management and Control of Complexity in Manufacturing, *Annals of the CIRP,* 43/2, 533-540, 1994.
6. E. Lin, I. Minis, D. Nau and W. Regli, Contribution to Virtual Manufacturing Background Research Phase I & Phase II, Final Report F33615-92-D-5812, *Institute for System Research - University of Maryland, 1995.*
7. Stojadinovic, M. Pilipovic and Z. Spasic, Development of Virtual PLC for Simulation and Education in Manufacturing, in: *Preprints of the 9th Symposium on Information Control in Manufacturing*, Nancy - Metz, France, Vol. III, 255-260, 1998.
8. M. Pilipović, Ž. Spasić, M. Stanojević, Piston Manufacturing and Informational Integration of Enterprise, *XVI International Conference "Science and Motor Vehicles",* pp. 271-274, Belgrade, 1997,.
9. Stojadinović, Contribution to the Development of Virtual Control System for Advanced Manufacturing, *Master Science Thesis*, Faculty of Mechanical Engineering, University of Belgrade, Belgrade, 1999. (In Serbian).
10. D. Vučković, Contribution to the Development of Virtual Manufacturing for Control in Advanced Automation on Internet Global Network, *Master Science Thesis*, Faculty of Mechanical Engineering, University of Belgrade, Belgrade, 2004. (In Serbian).
11. Dassault Systems, Catia Version 5 Release 11 - Documentation, Dassault Systems, 2003.
12. Seco, Turning, Main Catalogue, Seco Tools AB, Fagersta, 2000.

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MODEL OF THRUST FORCE AND TORQUE IN TAPPING OPERATIONS[1]

Kokotović B.,Puzović R., Tanović Lj., Kalajdžić M.[2]

***Abstract*:**

As well as another machining methods it is important to predict representative cutting forces in tapping operations. Developed procedure uses basic relations in orthogonal cutting, transfering them on every particular discrete part of cutting edge, using traditional transformations from orthogonal to oblique cutting, in order to calculate cutting forces on this elmentary edge. Resulting thrust force and torque in tapping are obtained through integration. Presented model is suitable for simple numerical simulation of thrust and torque in whole tapping cycle.

Ključne reči: *Cutting forces, model, tapping, simulation*

1. INTRODUCTION

There are a small number of texts in literature which deals with technology of tapping.In small-batch production it is partly clear. This method is used for machining of features which sometimes are not frequent, and in whole required time and energy resources contributes in small percentage. On the other hand, permanent interest in tapping technology could be explained by two facts. The first, it is safety required for threaded joints in many products, which is related to quality of manufacturing of threaded pairs. The second, there is specific philosophy of large volume production, where optimisation of each operation, including tapping, leads to significant benefits. Actual research activities in tapping technology are concerned on new materials for taps, optimizaton of tap geometries and cutting parameters and new techologies for manufacturing of taps. It is useful to have reliable model for cutting forces required for various calculations in technology design. Model which is oriented to simulation, for obtaining profile of tapping thrust force and torque is presented in this paper.

2. MODEL OF THRUST FORCE AND TORQUE IN TAPPING

During the tapping cycle cutting forces are drastically changing. Thrust force and torque by full immersion of cutting section of tap used as representative values for such operations. Dynamic change of torque, for example, is shown in figure 1 for two cases of tapping operations (tapping in blind hole and in through hole). Maximum values that appears in phase B (same situation is for axial thrust force) are important for phases in technology design process which are related to choice of fixture, tool and tooling (holder with coupling). Besides maximum values, it is useful to predict the change of thrust and torque in whole tapping cycle for implementation of automatic monitoring of process [9] in high volume production. This paper presents model for axial thrust force and torque derived from model of cutting forces in orthogonal cutting and their transformations in oblique cutting [10]. This model is developed for obtaining profiles of thrust force and torque for specified geometry of tap (cutting section and calibrating section; figure 2) through simple computer simulation.

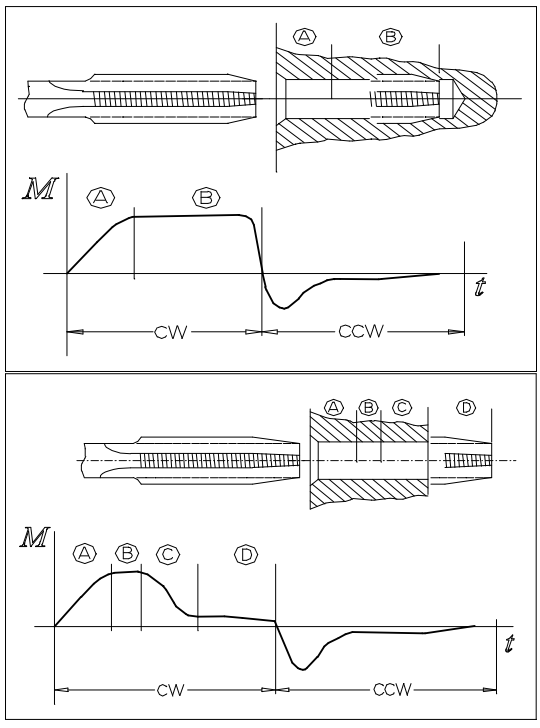

Figure 1. Change in torque durig the tapping cycle

[1] Rad se odnosi na rezultate istraživanja u okviru projekata koje finansira Ministarstvo nauke i zaštite životne sredine.
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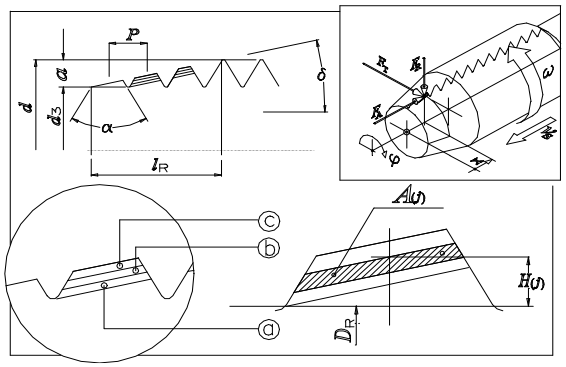


*Parameters of tap and tapping operation: **α**-angle of thread profile; **η**-thread helix angle tgη=P/dπ; **δ**-inclination of cutting section; **L_R**- cutting section length of tap; **z**-number of flutes; **d_3**-root diameter of tap; **a**-cutting depth, a=(d-D_R)/2; **D_R**-diameter of hole; **b**-max. width of unreformed, **b**=2a tg(α/2); **x**-axial position of cutting edge*

Figure 2. Unreformed cross section of chip in tapping

If the unreformed chip area $A(j)$ on particular tooth of cutting section is approximated with regular trapezoid, than it will be:

$$A(j) = b\left(1 - \frac{H_j}{2a}\right)(H_j - H_{j-1})$$

$$H(j) = x(j)\ \mathrm{tg}(\delta)$$

$$H(j) = (a\,\mathrm{tg}(\frac{\alpha}{2}) + (j-1)\frac{P}{z})\,\mathrm{tg}\,\delta\ ,\quad j = 1,2,...,N_R$$

$$x(j) = a\ \mathrm{tg}(\frac{\alpha}{2}) + \frac{(j-1)P}{z}$$

Equations for force components in oblique cutting are derived from transformations of orthogonal to oblique cutting [10]:

$$F_1 = K_{tC}\,A + K_{tE}L$$

$$F_3 = K_{fC}\,A + K_{fE}L$$

$$F_2 = K_{rC}\,A + K_{rE}L$$

Where cutting coefficients are:

$$K_{tC} = B\left[\cos(\rho-\gamma) + \mathrm{tg}^2\,\eta\,\sin\rho\right]$$

$$K_{fC} = B\frac{\sin(\rho-\gamma)}{\cos\eta}$$

$$K_{rC} = B\ \mathrm{tg}\,\eta\left[\cos(\rho-\gamma) - \sin\rho\right]$$, where are

$$B = \frac{\tau_S}{\sin\phi\sqrt{\cos^2(\phi+\rho-\gamma) + \mathrm{tg}^2\,\eta\,\sin^2\rho}}$$

Edge forces (related to friction effects by small depth of cut) F_{iE} (i=1,2,3) are proportional to the length of particular immersed cutting edge $L(j) \approx (1/a)(a - H(j))(b + 2a/\cos(\alpha/2))$ for edges on cutting section and $L(j) \approx 2a/\cos(\alpha/2))$, or calibrating sectoin. There is : ϕ - shear angle in cutting zone, τ_S - shear stress, γ -rake angle, ρ - friction angle. There are two ways to obtain of constants K_{iC} i K_{iE} ($i=t, r, f$). One is to use results from tests (turning of tube) with orthogonal cutting (used for verification in this research). The second procedure assumes co called mechanistic approach, also based on experiments.

Cutting speed has direction of tangent on thread helix and , in case of tap with straight flutes, contribution of cutting edge of particular tooth to tangential and axial component of cutting force will be:

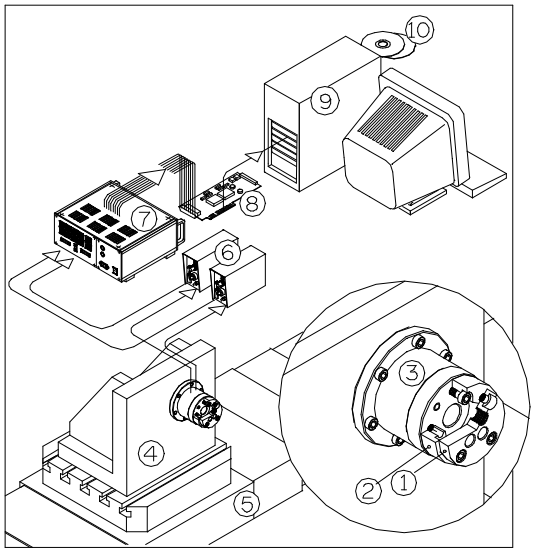
$$\mathrm{E}^{\mathrm{t}}(\mathrm{l}) = \left[\mathrm{K}^{\mathrm{tC}}\,\forall(\mathrm{l}) + \mathrm{K}^{\mathrm{tE}}\Gamma(\mathrm{l})\right]\cos\mathbf{l} + \left[\mathrm{K}^{\mathrm{tC}}\,\forall(\mathrm{l}) + \mathrm{K}^{\mathrm{tE}}\Gamma(\mathrm{l})\right]\sin\mathbf{l}$$

$$\mathrm{E}^{\mathrm{g}}(\mathrm{l}) = \left[\mathrm{K}^{\mathrm{fC}}\,\forall(\mathrm{l}) + \mathrm{K}^{\mathrm{fE}}\Gamma(\mathrm{l})\right]\sin\mathbf{l} - \left[\mathrm{K}^{\mathrm{tC}}\,\forall(\mathrm{l}) + \mathrm{K}^{\mathrm{tE}}\Gamma(\mathrm{l})\right]\cos\mathbf{l}$$

For cutting edges on calibrating section of tool it is assumed that exist just edge component of cutting force. In given moment, resulting thrust force and resulting torque are sums of contributions of all immersed cutting edges:

$$F_a = \sum_{j=1}^{N_R} F_a(j) \quad , \quad M = \frac{d}{2}\sum_{j=1}^{N_R} F_t(j)\,.$$

2.1. Experimental setup



1- Work piece (disc); 2- Distant ring;3- Two component piezoelectric dynamometer KISTLER 9271A;4- Fixture;5- Table of machining center HMC500; 6- Amplifiers KISTLER 5007;7- Module for conditioning and isolation ED 1778AP; 8- PC module for data acquisition ED2000; 9-PC; 10- DAQ software

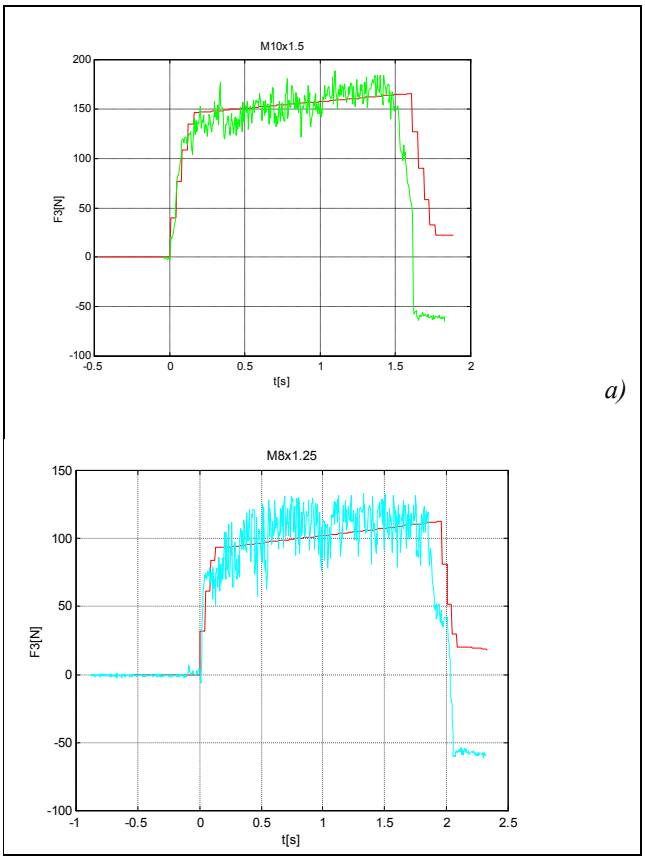
Figure 3. Experimental setup for acquisition of thrust force and torque during the tapping cycle

As a part of wider research in the field of machining of threaded holes with tap a large number of experiments were conducted. From necessity to work with different cutting speeds and have appropriate feed speed according to actual tap pitch, experiments were conducted on numerically controlled machine tool

(horizontal machining center LOLA HMC500). Installation which was used, with piezoelectric force+torque transducer, components for conditioning , acquisition and digital signal processing is shown on figure 3.

2.2. Model verification

Figure 4 shows graphs of thrust force and torque in tapping operations, for two tap with metric normal profile (M8 and M10). Work piece material was Č.1730 (JUS). Through hole depths were 20mm for both examples. Tapping cycle was programmed to ensure that cutting section of tap pass through the end of hole, in working stroke. Tap are with straight flutes both with 3 flutes. Geometry and dimensions of tap are according to DIN 376(1) Form C (tap with thin shaft, short cutting section, δ=20°). Simulation is based on previously described model. There are shown, in same graphs, results of experiments and results obtained through simulation, for equal conditions.



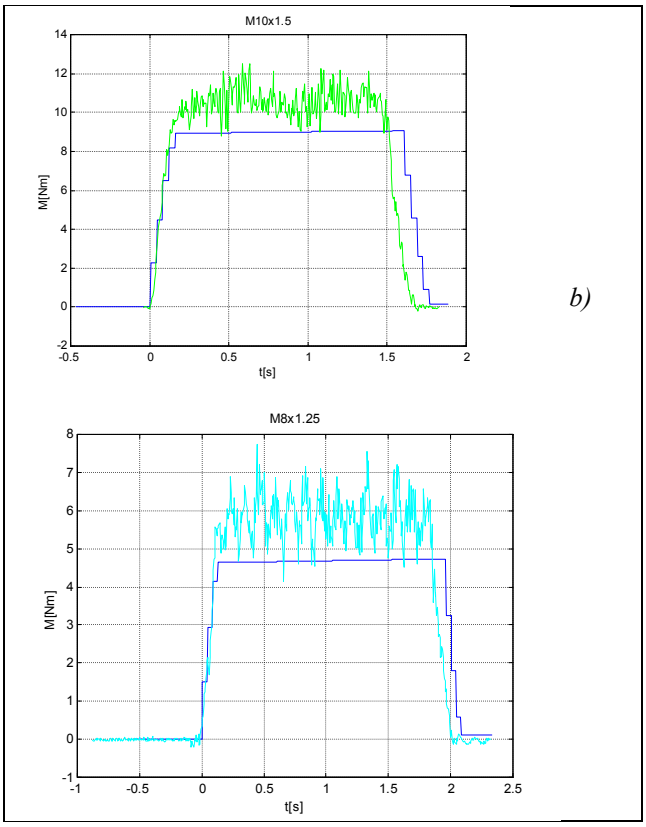


Figure 4. Comparing of experimental and simulation results for thrust force and torque during the tapping operations M10x1.5 i M8x1.2.

Remarkable deviations between experimental and simulation results are expected. The nature of tapping process and cutting forces in tapping is more complex comparing to proposed model. Part of inaccuracy of model results from experimental obtaining of model constants (specific cutting forces) used in calculations of forces for every particular cutting edge. Also there are details referred to coolant and cooling, orientation of tapping axis, small deviations of diameter of previously machined holes, use of specific tool holders, and so on. As most important, proposed model does not consider the real mechanism of chip forming in tapping operations. During the tapping each particular tooth on cutting section of tap has three cutting edges (one longer than two others) with different orientation, acting on work piece material. There is no relief edge in traditional manner. This results in higher cutting forces as well as in edge forces. As a rule, such chip forming process, similar to threading operations on lathe, with radial approach of tool, should be avoided in machining whenever is possible. Good results, tested in experiments, were obtained through simulation for taps with straight flutes. For different geometries of taps it is necessary to modify calculation of underfomed chip thickness and, during simulation, modify calculating of triggering moments for each particular cuting edge.

3. CONCLUSION

Presented model is based on approach which was succesfuly used for modelling of cutting forces in turning, milling and drilling operations . This approach includes integration of force components acting on dicrete parts of cutting edge, which are engaged into workpiece material, and project them on directions of main force components acting on the entire tool. Presented model of thrust force and torque is suitable for simulation.

Besides simulatoin of regular condition in tapping operation this model allows insight in influence of particular disturbing factors such as breakege of some cutting edges or tool wear. This could be used in training of systems for automatic monitoring of tapping process. Current research are expected to provide better model which would respect specific mechanism of chip forming in tapping and its influence on cutting forces, and accuracy and quality of machied internal threads.

4. LITERATURA

[1]Jovičić M., Obrada rezanjem teškoobradljivih metala i legura, Mašinski fakultet, Beograd, 1992.

[2]Oberg, E., Jones, F. D., Horton, H. L., Machinery's Handbook, 23rd Edition, Industrial Press Inc., New York, 1990.

[3]Ordinarceva, I., Spravočnik instrumentalšika, Mašinostroenije, Lenjingrad, 1987.

[4]Popović, B., Optimizacija reznih mogućnosti ureznika i procesa urezivanja navoja, Doktorska disertacija, Beograd, 1975.

[5]Tanović Lj., i dr., Istraživanja u oblasti obrade bušenjem i rezanjem navoja, međunarodna naučna konferencija, Teška mašinogradnja ’02, Zbornik radova, Kraljevo, 2002.

[6]Cincinnati: Machinability Data Center, Machining Data Handbook, rd ed., Vol 3, 1992.

[7]Katalozi proizvođača alata (FRA-Čačak, IAT-Trebinje, Jugoalat-Novi Sad, Coromant, Seco, Corun, i dr.)

[8]Standardi (JUS, DIN, GOST, ANSI/ASMT)

[9]Petuelli G., Blum G. , Wissenbasierte Ueberwachung von Gewindeformprozessen, Werkstatts technik Nr. 89. pp.47-51, 1999.

[10]Altintas Y. , Manufacturing automation, Cambridge University Press, Cambridge, UK, 2000.

THE UNIFICATION OF THE MECHANICAL PRESS DRIVING MECHANISM

P. Popovic[1], Lj. Djordjevic[2], B Radicevic[3], M. Bjelic[4]

RESUME

The basic aim of this research is to find the possibilities of the unification of the mechanical press driving mechanism. There are certain directions and methodologies in the construction of the unified driving mechanisms in the group of mechanical presses having different pressure force and different press stroke number. A certain number of different applications are pointed considering huge number of various solutions of mechanical press driving mechanism.

***The main words**: driving mechanism, mechanical press, and unification.*

1. THE INTRODUCTION

Considering well-known patterns and methods, we deal with the problem of finding the possibilities of application a certain driving mechanism in the group of mechanical presses whose pressure force and press stroke number are different. Selecting the flywheel and analyzing its power usage we specify the domain of its application at the presses of specified pressure force and different number of press stroke

Producing groups of presses differed by pressure force and the number of press strokes, as the main characteristics, it is possible to produce some sub-systems as unified.

The main purpose of this research is to find, through the familiar patterns, the possibility of the application of the same driving mechanism in a certain number of mechanical presses. Here, we will try to show some directions in construction of mechanical press so that the complete system (driving motor-lamella and brake-reduction gear-excentric sheave axle, and possibly presser) could be the same at a few presses of the same group (presses of different pressure force and different press stroke number).

It is obvious that this is impossible for the whole group as the range of pressure force and press stroke number is huge, but it is possible to include reasonable range (excentric sheave 63 to 100 mp pressure or excentric sheave 100 with press strokes 50-80) what gives a lot of advantages in such conditions.

This can be done if we don't stick to the principle of dimensioning machine elements considering hardness. This factor can't be completely denied or neglected, but it is just pointed that it is not always the only one and the most important, so it can be denied if other factors are economically and technically justified.

To satisfy the other factors influencing more deeply the production profitability, trying to solve this problem we had to be aware of the fact that certain press elements are more or less over capacitated.

There are some of these factors:

1. The possibility of driving system serial production for individual or small serial production directly influences the decrease of product cost..
2. Certain funds are necessary for the testing of press group as the testing of driving system and all connected with it is done only once.
3. It is easier to supply the substitute of elements and framework in usage meaning that maintenance is easier in the workshops with more presses of the same group constructed on this way.

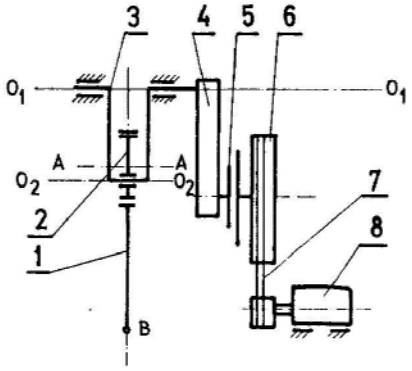


Figure 1. Universal model of mechanical curving press driving system

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2. THE DIRECTIONS FOR THE UNIFICATION OF DRIVING MECHANISM

To analyze this problem in details, we must set the scheme first consisting of elements: electric motor (8), flywheel (6), lamella and brake (5), reduction gear (4), shaft (4), connecting rod (1) and presser.
The application of certain driving system depends on the choice of flywheel.
The selection of flywheel: The selection of flywheel is made using the formula:

$$\left(GD^2\right)_m = \frac{7\cdot 10^6 \cdot P_m \cdot \lambda}{\beta \cdot n_{sm}^2 \cdot n_e \cdot S_k \cdot \left(2 - S_k\right)\cdot p} \quad [\text{daNm}^2] \quad (1)$$

where: $(GD^2)_m$ - GD^2 of flywheel is reduced on the axle of electric motor in $daNm^2$,

P_m - nominal power of driving motor in KW,

λ - Coefficient of motor overloading that is here from 1,7 to 2,2.

p - Coefficient representing the relation of real cycles to possible ones (for automatic work, p=1)

n_{sm} – Synchronized number of electric motor rotations per minute,

n_e – The press stroke number per minute,

S_k – Critical sliding of electro motor given in the formula:

$$S_k = S_H \cdot \left(\lambda + \sqrt{\lambda^2 - 1}\right) = S_H \cdot k \quad (2)$$

where:

$$S_H = \frac{n_{sm} - n_m}{n_{sm}} \quad (3)$$

- Nominal sliding of electric motor

n_m – Nominal number of electric motor rotations per minute

β - Coefficient that is the function of power coefficient γ and diagram coefficient of resistance moment α.

If we lack the data for β obtained by an experiment, we can get coefficient β by the formula:

$$\beta = 0{,}9 \cdot \sqrt{\frac{\gamma^2 - 1}{\alpha}} \quad (4)$$

where: γ - coefficient of engine power and it is usually from 1,1 to 1,3 and

α- coefficient of resistance moment which is usually from 0,5 to 1,0.

It is marked like this:

$$a = \frac{\lambda}{s_k \cdot \left(2 - s_k\right)\cdot p} \quad (5)$$

$$C_1 = a \cdot \frac{7\cdot 10^6}{n_{sn}^2} \quad (6)$$

$$C_2 = \frac{1}{\beta} = \frac{1}{0{,}9 \cdot \sqrt{\frac{\gamma^2 - 1}{\alpha}}} \quad (7)$$

equation (1) is now in following shape:

$$\left(GD^2\right)_m = C_1 \cdot C_2 \cdot \frac{P_m}{n_e} \quad [daNm^2] \quad (8)$$

Let's analyze, (5), (6) and (7):

1) The value of engine overloading coefficient (λ) is in relatively tight limits from 1,7 to 2,2 and it can be asserted that it has little influence (almost none) on the value of the formula (5), while the nominal sliding of electric motor makes the main influence (table. 1). For the burst work the value of coefficient a is given in the list T1 for, λ = 1,7 and λ = 2,2 with the practical average value.

A diagram on figure 2 is drawn according to the values on the list T 1.

2) Driving machines used for the mechanical presses are asynchronies three-phase short-circuited motors with 2, 4, 6, and 8 ends, with synchronized rotating number n_{sm} = 3000, 1500, 1000, and 750(rev/min). According to this, for all the electric motors, the burst work, it is possible to calculate the value of coefficient C_1, which is shown on the diagram and figure 3.

In the formula (7) we can see that C_2 is the function of coefficient λ i γ. Changing γ to 1,1 — 1,3 and α from 0,5 — 1,0 we get the values for C_2 as shown on the diagram in figure 4.

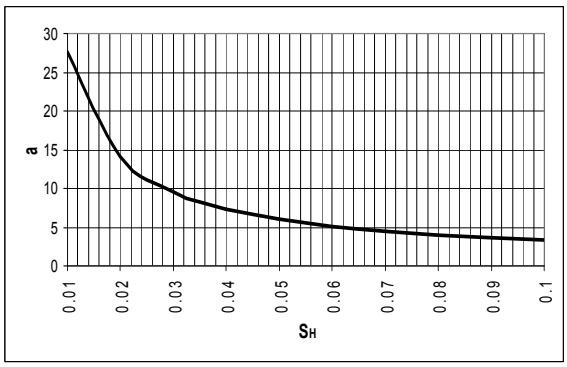

Figure 2.

It must be mentioned that nominal sliding for asynchronies three-phase short-circuited motor is not higher than 0,1.

As we defined the value of C_1 in function to S_H and C_2 in function to α and γ, we can easily define the and $(GD^2)_m$ of fly wheel using the formula (8) for the certain electric motor and press stroke number, with at first approximation supposed values for α and γ, define $(GD^2)_m$ of flywheel.

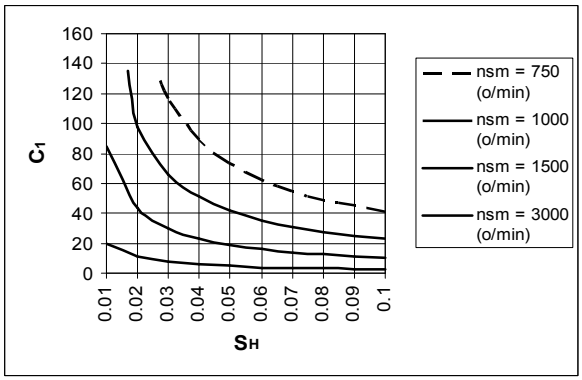

Figure 3.

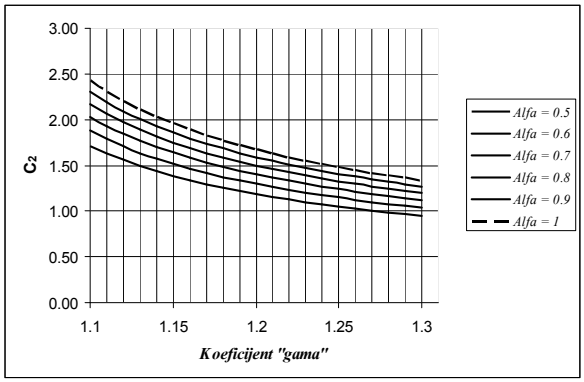

Figure 4.

Table T-1.

	a for S_H									
λ	0.10	0.09	0.08	0.07	0.06	0.05	0.04	0.03	0.02	0.01
1.7	3.28	3.57	3.95	4.43	5.10	6.00	7.40	9.65	14.3	28.1
2.2	3.34	3.61	3.97	4.44	5.04	5.91	7.23	9.40	13.8	27.0
	3.30	3.60	3.95	4.43	5.07	5.96	7.32	9.52	14.0	27.5

Defining the transmission ratio electric motor – flywheel we want, or which is suitable, considering lamella available and the dimensions we need to place the flywheel, we can easily define dimensions and weight of flywheel using the familiar formula:

$$\left(GD^2\right)_z = i_{mz}^2 \cdot \left(GD^2\right)_m \qquad (9)$$

As we defined the flywheel, we defined the lamella and the transmission ratio but reduction gear with transmission ratio, inlet and outlet rotating moments as well. In short, a mechanical press of certain possibilities is defined, and it represents a group of mechanical presses. Changing the pair of gear in redaction gear, or changing the press body and safety plates, we can get the other presses in the group with their characteristics, the presses with the other press stroke number or the other pressure force.

3. CONCLUSION

Analyzing the solution for the mechanical curving press of simple effect and analyzing its main functions we come up with a number of these machines that produce by deformation.

Analyzing the universal model of driving mechanism (without discussing its individual parts), we can identify possible concepts of variations and classify them.

We consider the solution by analyzing the laws of orbit changing and analyzing the number of work orbit cycles in working part of the machine, as these parameters are tightly connected with the solution for the driving mechanism.

The presented parameters show the complexity of finding the solution at the machines of static effect and wide range for the creativity of a constructor, which led to the large varieties of these machine types.

It is useful to consider the case of unified driving mechanism for the universal model of driving mechanism. Changing some of the components, the characteristics of the press inside the group are changed as well.

4. REFERENCES

[1] Popović P., Machines for the production by deformation (part I), Faculty of Mechanical Engineering, Nis, 1991.

[2] Popović P., Đurković A:, Contribution to the unification of mechanical press driving mechanism, Magazine “Technic” (Mechanical Engineering), Belgrade, 1965, XIV, br.10

[3] V. I. Vlasov, Krivosipnie kuznecno-pressovie masini. Teorija i proektirovanie, Moskva, 1982.

KNOWLEDGE BASE IN DEVELOPMENT EXPERT-CAPP SYSTEMS FOR ELECTRICAL DISCHARGE MACHINING TECHNOLOGY

D. Erić[1], G. Miodragović[2]

Abstract:

In this paper there has been given a presentation of the role knowledge base in designing machining for the erosimate with ware. The role of this knowledge base would be, first of all, to define all necessary elements of the CAPP process for EDM technology. That is, above all, making a decision about whether the processing by this technology is possible in a particular case, and then defining the type of processing, determination of processing regime, processing parameters and other elements of this process.

Key words: *Knowledge base, design CAPP system, electric discharge machining*

1. INTRODUCTION

In this paper to give is synthesis between Electrical Discharge Machining Technology (EDM), Computer Aided Process Planning systems for design technology and software tool for this systems. Purpose this compromise is to define intelligent knowledge base for technology process EDM.

2. EDM TECHNOLOGY TODAY AND TOMORROW

Now in world is actually next the assertion. Electrical Discharge Machining is no longer "non-conventional" or "non-standard" machining. Why ? In fact, EDM is now the fourth most popular machining process, selling more than all other processes expect milling, turning and grinding, with EDM sales increasing from about 0.5 percent of the 1960 machine tool market to about 6 percent of the 1998 market.

In the soft 1999 machine tool market, EDM' share increased further because EDM sales were off less than machine tool sales as a whole. The increasing strength of EDM is based on the rapid improvements in its price/performance rations, on the new applications made feasible by the improved performance economics and on a growing awareness of the advantages of EDM by the metalworking industry in general.

Sales and performance have increased dramatically for both wire and ram (die sinking) EDM, but the two processes have generally been out of phase with each other. Each process has been subject to important but different trends.
Wire EDM started from scratch in the early 1970s and has made steady progress, with the most rapid process improvements occuring from the mid 1980s to the mid 1990s. Progress occured in six key measures of price/performance. This is:

- speed,
- workpiece size,
- taper
- price
- accuracy and
- untended operation.

3. COMPUTER AIDED PROCESS PLANNING (CAPP)

One of the most important steps in converting a design concept into a manufactured product is process planning. The essence of that task is the creation of a complete package of information on how to perform the manufacturing process, which may include work instructions for the shop floor, a bill of material, a quality control plan, tool planning, and so on. Also, there may be links to other manufacturing systems such as MRP (material requirements planning), PDM (product data management), time standards, engineering and manufacturing change control, shopfloor control and data collection systems. In most cases, this initial package of information ultimately determines the final cost and quality of the product.

Traditionally, manufacturing engineers produced the necessary process planning documents from scratch

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using manual techniques. That required the retrieval and manipulation of a great deal of information from many sources including established standards, machinability data, machine capabilities, tooling inventories, stock availability and, hopefully, existing practice. The resulting process plan was then manifest in the form of printed text, lists and drawings. The introduction of computers into manufacturing has certainly made the planning function more efficient, but there are additional advantages. For one, computers can readily perform vast numbers of comparisons and, therefore, many more alternative plans can be explored than would be practical in a manual setup. Also, the application of computers can bring greater uniformity to process planning. Ask ten engineers to develop a process plan for the same part, and you will probably end up with ten different plans. Not only does this mean some plans will be better than others, but also that essentially similar jobs planned at different times will be done differently. However, with the comparative capabilities brought about by computer-aided process planning (CAPP), it becomes easier to answer the questions: Which plan best utilizes the facility's capabilities ? Which can be used for estimating future work ? Which is best for scheduling and shop loading ? And most important, which plan reflects the best practice based on past experience ?

While CAPP can indeed answer these questions, to be of optimum value, particularly in larger manufacturing facilities, companies must carefully consider its implementation and integration with other systems. Here are some factors to think about if CAPP is to achieve its potential.

4. KNOWLEDGE BASE FOR EDM TECHNOLOGY

The EDM process on an erosimat with wire is used for the processes of precise cutting in our company. The preciseness of the machining comes to several microns only. The machine is CNC (Computer Numerical Control) oper`ated, and Mecanic-CAM software is used as a software support. For programming in order that this process should be as optimal as possible, there has been developed a project to support technology defining by means of an expert system. The rule of this expert system is that by activating its knowledge base it should offer a wide range of answers which are necessary in the process of technology defining. These answers in the first place relate to the following elements of the EDM technology:

- types machining with which it is possible to operate,
- choice of tools (type, quality),
- choice of suitable systems (relations) of machining and
- defining of input parameters.

Designer of technology process must be had great experience before is sitting down to the computer and start by work. Because that done attempt with involving some elements of artificial intelligence to enable work to designer that has not sufficiently experience in that areas.

For this knowledge base we used knowledge from CNC-tool AG-100, knowledge from working-piece and knowledge from tools for working. Mecanic is software for CAM design (production programs for CNC-tool). This programming package we are using for creation technological process at tool for erosion. Host computer is Hewlett-Packard systems series 9000 with output at punched tape.

During technology defining for EDM, the knowledge base has the leading role in two segments of designing:

-defining of processing possibilities on erosimate,
-defining of processing parameters if EDM processing is possible.

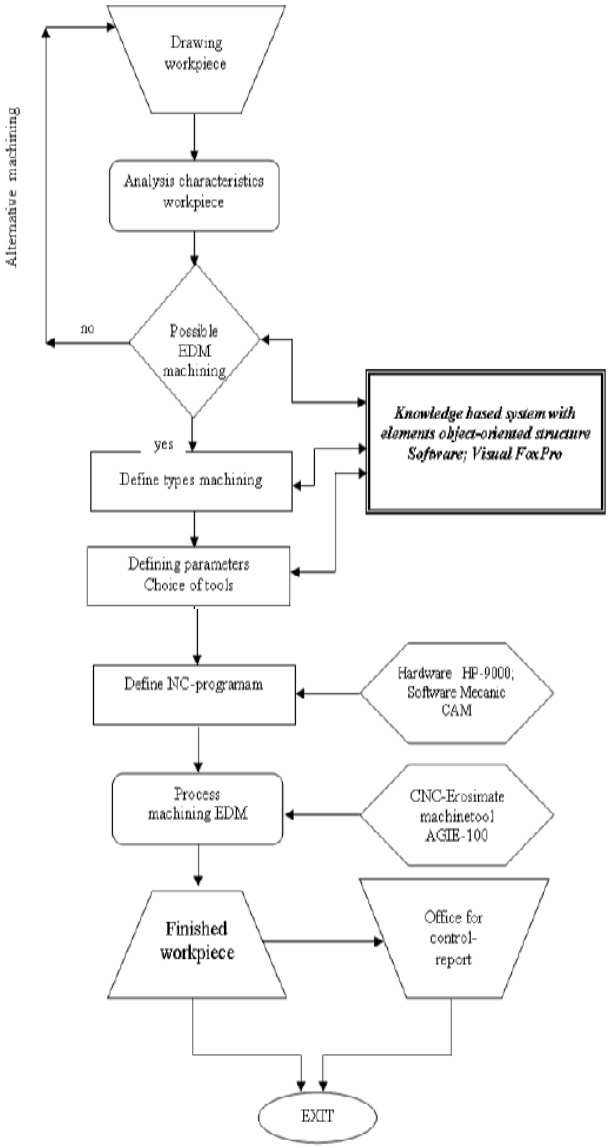

Figure 1.

The following segments, such as making of NC-programms have already gained a support expressed through software "Mecanic-CAM" and hardware "Hewlett Packard-9000". For development knowledge base we are used software Visual FoxPro.
The Figure 1 yes representation flow activity Computer Aided Process Planning for EDM machining with support knowledge base.
Visual FoxPro uses objects as the main form of knowledge representation. Physical entities or abstract concepts are grouped into a hierarchical structure of classes, subclasses and instances. Characteristics, or slots, describe each class and are inherited by any object below in the object hierarchy. In Visual FoxPro is to represent all characteristics object-oriented programming. This is following property: hierarchy class, subclassing, inheritance and encapsulation.

The program can obtain new information from established information throughout object-oriented programming, and functional programming.

5. CONCLUSION

CIM (Computer Integrated Manufacturing) is one base goals in past of research in technological processes. Today is certain what object-oriented structure would be one the most important tools in realization of CIM structures. This paper is attempt of implementation some elements object-oriented programming in knowledge base for classical Computer Aided Manufacturing (CAM) and Computer Aided Process Planing (CAPP) technologies. This is possibly concept for future expert CAM/CAPP-system for EDM precise cutting.

REFERENCES

1. Arlabose,F., Knowledge-based system for manufacturing, 3rd CIM Europe Conference, 19-21 May 1987, Knutsford, U.K.
2. Hentzen W., Visual FoxPro 3.0. (Prevod Andon Kartalovski). Mikro-knjiga, Beograd 1995.
3. Devedzic,V., Expert systems for work in real time, Institute "Mihajlo Pupin", 1994, Belgrade, p19-22.
4. Milicev,D., Objektno-orijentisano programiranje na jeziku C++, Mikroknjiga, Beograd, 1995.
5. Durkin,J., Expert Systems - design and development, Macmillian Publishing Company, New York, 1994.
6. Eric,D.,Drobnjak,V.,Milosevic,M.,Radovic,D., CAM-technology and possible role expert systems in this process, International Conference "Industrijski sistemi", Milocer,Yugoslavia,October,1996.
7. Eric,D.,Application object-oriented programming tool for building expert systems in CAM-technology, YU-INFO'96, April,1996.
8. Eric,D., Expert systems - support in CAM technology, The 15th International Conference on Production Research, 9th-12th August 1999, University of Limerick, Ireland.
9. Eric,M.D., Jekic,S., Some aspects of Using Artificial Intelligence in the CAPP Systems for EDM Technology, INFORMS Annual Meeting, November 17-20, 2002, San Jose California, U.S.A
10. Eric,M.D., Jekic,S., Knowledge Base with Object-Oriented structure for Machining Technology Process, 4th International Conference RaDMI-2004, 31.Avg.- 04 Sept. 2004, Zlatibor, Serbia and Montenegro.

CLASSIFICATION, CHARACTERISTICS AND APPLICATION OF THE CERAMIC CUTTING TOOLS

Predrag. Dašić[1)], Ratomir Ječmenica[2)], Valeriy Kuzin[3)]

Abstract:

In this paper the analysis of classification and characteristics of materials of cutting tools for multi-cutting indexable inserts (MCII) or mechanical fixing of cutting inserts (MFCI) and classification and characteristics of ceramic cutting tools. Through some examples are given the efects of the application of ceramic cutting tools.

Keywords: *metalworking, ceramic cutting tools, efficiency application*

1. INTRODUCTION

Application of modern high produced technological and working systems, it is present the constant tendency for reduction as main, so and accessory time, specially that part of accessory time which is spent for change and sharpening of cutting tool. By that it is necessary in one firm to use generally standards cutting tools and, percentile only small number of specially manufactured in peculiar produced section or in co-operation. In region of metalworking this is realized in big proportion by large application of cutting tools with mechanical fixing of cutting inserts (MFCI) or also multi-cutting indexable inserts (MCII) for turning, planing, drilling and milling. MCII that are in big proportion push back the rest tips of cutting tools specially the cutting tools from HSS and with solded inserts. By that reason it is present in development and perfectintg that cutting tools the have a big attention last years, specially in development the basis components of cutting tools (figure 1) [1-3]:

- the development of materials for cutting tools;
- the development of cutting geometry, especially the elements for bending and fragiling the turnings and
- the development of fixings and clamping the indexiable cutting inserts.

therefore the big importance have the correct choice of all three components, respectively the choice whole structure of cutting tools with mechanical fixing of cutting inserts.

In field of material working are used MCII produced from [1-5,9-12]:

- carbides,
- multi-coated carbides,
- cermet,
- cutting ceramics,
- CBN (***C**ubic **B**oron **N**itride*) and
- PCD (***P**oly-**C**rystalline **D**iamond*).

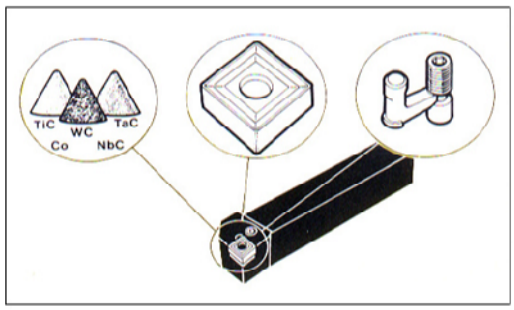

Fig. 1: *Basic cutting tools components with mechanical fixing of cutting inserts*

2. CLASSIFICATION AND CHARACTERISTICS OF MATERIALS OF CUTTING TOOLS FOR MCII

MCII are manufactured from powder by various methods of sintering. In world nowadays most extensive are the following methods: cold pressing with alternate sintering, warn pressing and warn izostatic pressing. Last years in world for production of new tips of materials for cutting tools widely is used method of casting under pressure of mixture powder. For enlargement of physical-mechanical and exploitational characteristics cutting inserts are subject of mechanical working. From showed is evident that it is a question of metals and semimetals chemicals fusions from class (figure 2) [2-4,7,10]:

- oxide,
- carbide and
- nitride.

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Structure of all three tips materials for cutting tools permit the forming of mixed crystals, that is permit the forming of dispersion one phase in other phase. Using such possibilities of alloying the combinations are possible as in frame of one tip oxides, carbides or nitrides, as and combinations of corresponding components various tips. At this way are formed the undertips: oxi-nitride, carb-oxide, carbo-nitride and carboxi-nitride. From figure 2 is easy able to recognise the structure ones tips materials for cutting tools compared to classics divisions.

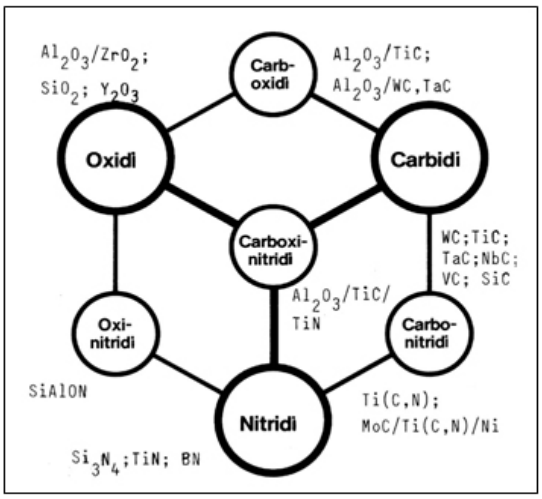

Fig. 2: *Classification of materials for cutting tools which are produced from powder various methods of sintering*

Cutting tool must have the following characteristics in order to produce good quality and economical parts:

- Hardness and strength of the cutting tool must be maintained at elevated temperatures also called hot hardness;
- Toughness of cutting tools is needed so that tools don't chip or fracture, especially during interrupted cutting operations;
- Wear resistance means the attainment of acceptable tool life before tools need to be replaced.

Basic characteristics of cutting-tool materials are shown in table 1 [9,10].

Table 1: *Basic characteristics of cutting tool materials*

Cutting-tool Material	Hardness HV 30 (N/mm²)	Temperature of steadiness tools (°C)	Solidity on pressure (N/mm²)	Solidity on bending (N/mm²)	Density (kg/dm³)	Young's modules x10³ (N/mm²)
High speed steel	7500-10000	600-800	2500-3500	2500-3800	8,0-8,8	260-300
Carbides	13000-17000	1100-1200	4000-5900	800-2200	6,0-15,0	430-630
Cutting ceramics	14000-24000	1300-1800	2500-4500	300-700	3,8-7,0	300-400
Cubic boron nitride	45000	1500	4000	600	3,45	680
Diamond	to 70000	600	3000	300	3,5	900-1000

Dependence of hot hardness and wear resistance from strength and toughness for different of tools material is shown on figure 3 [2-3.5,9-10] and speed ranges for various cutting –tool materials are shown in figure 4 [9].

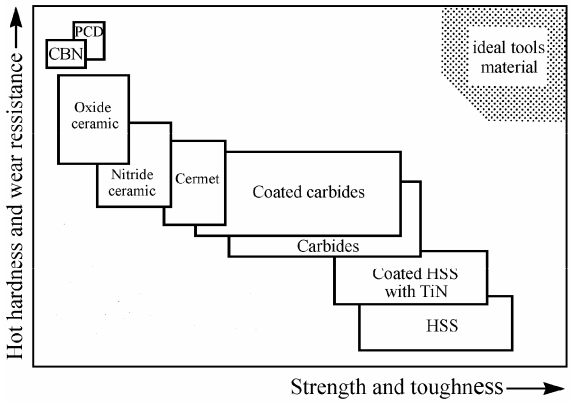

Fig. 3: *Dependence of hot hardness and wear resistance from strength and toughness for different tools material*

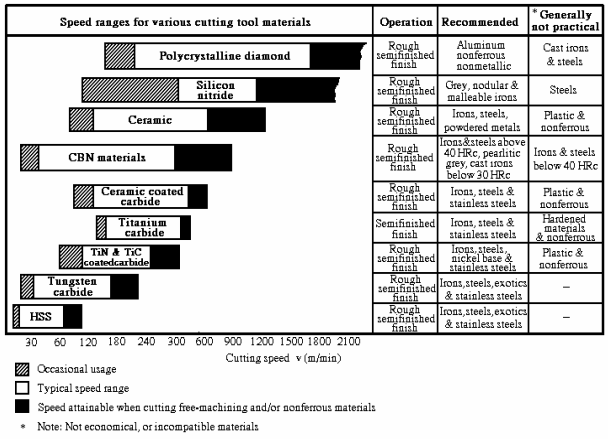

Fig. 4: *Speed ranges for various cutting–tool materials*

3. CLASSIFICATION AND CHARACTERISTICS OF CERAMIC CUTTING TOOLS

Ceramic cutting tool are made of metallic and non-metallic particles from oxide, carbide and nitride, which basic features are: high hardness, high resistance to wear and pressure, high chemical stability on high temperatures.

There are three basic groups of ceramic cutting tool materials (figure 4) [2-5,7]:

- oxide ceramic (oxides),
- mixed ceramic (oxides+carbides) and
- nitride ceramic (nitrides+oxides).

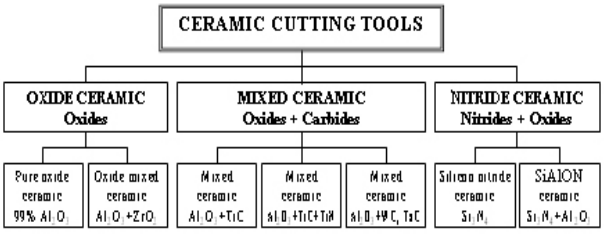

Fig. 4: *Classification of ceramic cutting tools*

Oxide ceramic applies for rough and finish off processing of cast iron and steel with high cutting speeds. Cutting tools of high speed steel and hard metal

can be changed with oxide ceramic cutting tools in turning, milling and planing.

Mixed ceramic cutting tool is suitable for rough and finish off processing by turning and milling of cast iron, steel for thermal processing, harded steel with hardness up to 65 HRC and high speed steel, too, all of them with cutting speed which is 3-6 times higher than speed of hard metal. Eliminating of drosses, sands and cavities are prerequisite for economical applying of mixed ceramic cutting tools. In last time, grinding is changed with grating finish of with the help of ceramic cutting tools in metalworking industry.

Nitride ceramic is used in branch of metal turning and milling processes on cast iron and other castings with adversely cutting conditions, with interruptions of process, with use of cooling and lubricating fluids, or with high requests for accurate dimension with medium and high cutting speeds. Use of nitride ceramic is able on machine tools with small powers which is not suitable for application of oxide ceramics. According to high prices of nitride ceramic, it applies in mass production particularly on automatic lines and flexible technological systems.

Basic characteristics of ceramic cutting-tool materials from firm SPK-Feldmuhle are shown in table 2 [1-3].

Table 2: *Basic characteristics of ceramic cutting-tool materials from firm SPK-Feldmuhle*

Grade	SN 60	SN 80	SH 1	SH 20F	SL 100	SL 200
Composite	Al_2O_3+ZrO_2 ≈90%+10%	Al_2O_3+ZrO_2 ≈80%+20%	Al_2O_3+TiC ≈90%+10%	Al_2O_3+TiC ≈80%+20%	Si_3N_4+TiC	Si_3N_4+ Al_2O_3
Colour of insert	White	while	black	black	black	black
Code colour	Blue	violet	white	yellow	green	red
Code number (=last digit of ref.no.)	…5	…4	…6	…9	…1	…2
Density [g/cm^3]	3,97	4,16	4,30	4,28	3,30	3,25
Grain size [µm]	<3	<2	<2	<2	<2	<2
E-module [KN/mm^2]	340	340	370	370	300	300
Vickers hardness HV	2.000	2.000	2.500	2.100	1.700	1.500
Breaking strength Kl_c [N/mm$^{3/2}$]	175	210	160	170	250	220
Bending strength σ_B [N/mm^2]	450	600	600	600	800	750

Ceramic cutting tools have some advantages in respect to hard metal concering the filings shape and posibility to apply higher cutting speeds. It is enough in about 80 % cases to choose the right facet of a replaceable cutting plate and vary cutting speed in order to obtain good filing shape (figure 5) [2-4].

For the remaining 20 % cases where good filing shape is not schieved, cutting tools manufacturer developed various ways for making complex-cannals on the front surface [2-4].

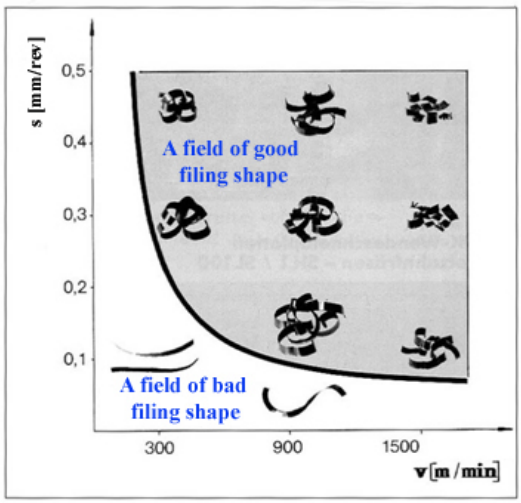

Fig. 5: *A field of good filing shape for ceramic cutting tools in v-s diagram*

4. EXAMPLES OF APPLICATIONS CERAMIC CUTTING TOOLS

Ceramic cutting tools with MCII in region of material working magnified hardness are used for finish working of improved and hardened steels by turning, planing, drilling and milling. In many cases this operations can exchange the operation of grinding.

Effectiveness of working cited ceramic cutting tools in much depend from correct chose material for cutting tools and whole structure of cutting tool. Negative effects who can to report oneself by reason of wrong choose of material for cutting tools on illustrate best by used oxide and mixed cutting ceramics at finish turning of harded steel with hardness 52÷54 HRC. By that for value of tool wear VB=0,25 mm it is tool steadiness from mixed cutting ceramics 55 min, and tool steadiness from oxide ceramics only 13 min.

Example 1: On figure 6 it is presented the operation of finishing turning of the small gear from harded steel hardness 62÷63 HRC by mixed cutting ceramics SH1 by firm SPK Feldmuhle, by which is realized by demanded roughness worked of surface R_t=8 [µm]. The elements cutting regime were: cutting depth a=0,15÷0,2 [mm], cutting speed v=100÷180 [m/min], feed s=0,08 [mm/rev] and nose radius r=1,2 [mm]. For difference from grinding, the working costs by finish turning are reduced for 25 % (fig ure 6) [3-4].

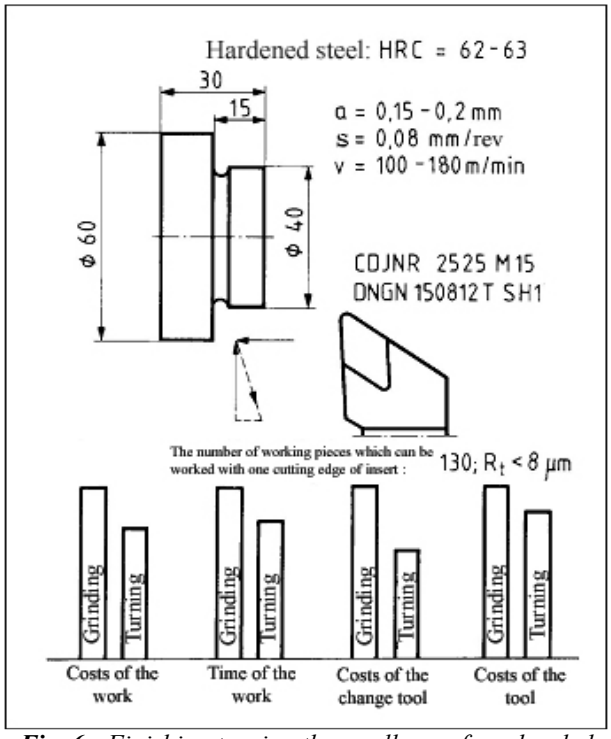

Fig. 6: *Finishing turning the small gear from harded steel hardness 62÷63 HRC with mixed cutting ceramics*

Example 2: On figure 7 it is presented the operation of finishing turning the cover from cast iron FC 20 (according to GOST standard) by nitride cutting ceramics SP4 by firm NTK Cutting Tools. The elements cutting regime were: cutting depth a=2÷3 [mm], cutting speed v=700 [m/min] and feed s=0,2 [mm/rev]. For difference from turning with oxide ceramic the number of working pieces which can be worked with one cutting edge of insert is increased for four multiply [11].

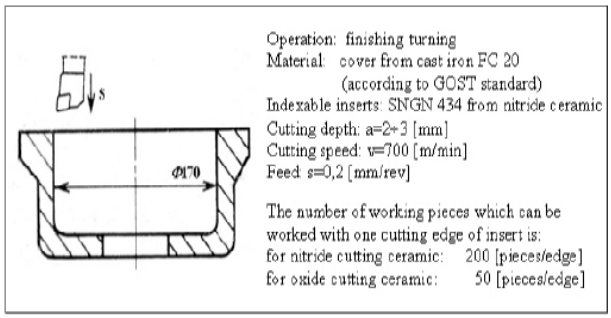

Fig. 7: *Finishing turning the cover from cast iron FC 20 with nitride cutting ceramics*

5. CONCLUSIONS

Effectiveness of working by modern ceramic cutting tools in much depend from correct chose material for cutting tool and whole structure of cutting tool.
Application of ceramic cutting tools it is possible exchange the finish operation grinding by turning, planing, drilling and milling, what show and tree examples cited.

REFERENCES

[1] *Coromant Zerspanungstechnik, Drehen,* Handbuch, Copyright Sandvik Coromant, 1985. - 203 p.

[2] Dašić P.: *Analiza mogućnosti primene reznih alata od keramike,* Zbornik radova VII Međunarodne naučno-stručne konferencije Fleksibilne tehnologije mma′2000, s. 5-6, 8. juna 2000, Novi Sad

[3] Dašić P., Ječmenica R.: *Analiza efektivnosti obrade primenom reznih alata od keramike,* časopis Tribologija u industriji (ISSN 0351-1642), Kragujevac, god. XIII (1991.) br. 2, s. 51-55

[4] Dworak U.: *SPK Schneidkeramik, Die Entwieklung zum Hochleistungs Schneidstoff fur die tagliche Praxis,* In: Referate SPK Schneidkeramik - Tage'84, Dusseldorf, 1984., p. 4-10

[5] Chneider G.: *Applied cutting tool Engineering,* Tooling&Productions, 2001. (Available on Web-site: http://toolingandproduction.com/)

[6] Кузин В. В.: *Теоретические основы повышения работоспособности керамических инструментов*, Сб. трудов «Научно-практические аспекты автоматизированного машиностроения». М. 1991 г. с. 121-122

[7] Momper J. F.: *Untersuchung zum standvermogen keramischer werkzeugschneiden beim drehen unter besonderer berucksichtigung der schneideneingriffsverhaltnisse,* dissertation, Vom Fachbereich Maschinenwesen der Universitat Kaiserslautern, 1985.

[8] Nedić B., Kuzin V. V., Ječmenica R., Popov F. V.: *Pesrpektive korišćenja reznih alata od silicijum nitridne keramike sa ciljem povećanja efektivnosti obradnih procesa,* časopis Tribologija u industriji (ISSN 0351-1642), Kragujevac, god. XVII (1995) br. 1, s. 18-27

[9] Radovanović M., Dašić P., Ječmenica R.: *Advanced cutting tool materials,* Proceedings of 2nd International Conference ″Research and Development in Mechanical Industy - RaDMI 2002″ (ISBN 86-83803-02-3 for Volume 1 in hard copy and electronic form on CD-ROM), p. 346-351, Vrnjačka Banja, Yugoslavia, 01 - 04. September 2002.

[10] Spur G. and Stoferle T.: *Handbuch der Fertigungstechnik, Spanen,* Carl Hanser Verlag, Munchen, Wien, 1980.

[11] Старков К. В., Кузин В. В.: *Инструментальное и технологическое оснашение металло-обрабатывающего производсва,* Обзорная информация ВНИИТЭМР серия 8 выпуск 5 (ISSN 0235-2818), Москва, 1988. – 60 с.

[12] Tanović Lj.: *Tehnologija proizvodnje savremenih reznih elemenata alata,* Mašinski fakultet (ISBN 86-7083-294-1), Beograd, 1997.

[13] Whitney E. D.: *Ceramic cutting tools, Materials, development and performance,* Hard Cover, 1994.

CLASSIFICATION, CHARACTERISTICS AND APPLICATION OF THE CERAMIC CUTTING TOOLS

Predrag. Dašić[1)], Ratomir Ječmenica[2)], Valeriy Kuzin[3)]

Abstract: *This paper analysis classification and characteristics of materials of cutting tools for multi-cutting indexable inserts (MCII) or mechanical fixing of cutting inserts (MFCI) and classification and characteristics of ceramic cutting tools. Through some examples are given the efects of the application of ceramic cutting tools.*
Keywords: *metalworking, ceramic cutting tools, efficiency application*

1. INTRODUCTION

Application of modern high produced technological and working systems, it is present the constant tendency for reduction as main, so and accessory time, specially that part of accessory time which is spent for change and sharpening of cutting tool. By that it is necessary in one firm to use generally standards cutting tools and, percentile only small number of specially manufactured in peculiar produced section or in co-operation. In region of metalworking this is realized in big proportion by large application of cutting tools with mechanical fixing of cutting inserts (MFCI) or also multi-cutting indexable inserts (MCII) for turning, planing, drilling and milling. MCII that are in big proportion push back the rest tips of cutting tools specially the cutting tools from HSS and with solded inserts. By that reason it is present in development and perfectintg that cutting tools the have a big attention last years, specially in development the basis components of cutting tools (figure 1) [1-3]:

- the development of materials for cutting tools;
- the development of cutting geometry, especially the elements for bending and fragiling the turnings and
- the development of fixings and clamping the indexiable cutting inserts.

therefore the big importance have the correct choice of all three components, respectively the choice whole structure of cutting tools with mechanical fixing of cutting inserts.

In field of material working are used MCII produced from [1-5,9-12]:

- carbides,
- multi-coated carbides,
- cermet,
- cutting ceramics,
- CBN (***C**ubic **B**oron **N**itride*) and
- PCD (***P**oly-**C**rystalline **D**iamond*).

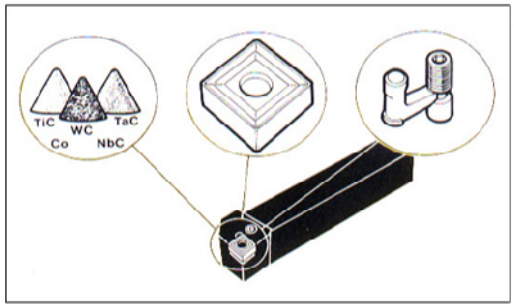

Fig. 1: *Basic cutting tools components with mechanical fixing of cutting inserts*

2. CLASSIFICATION AND CHARACTERISTICS OF MATERIALS OF CUTTING TOOLS FOR MCII

MCII are manufactured from powder by various methods of sintering. In world nowadays most extensive are the following methods: cold pressing with alternate sintering, warn pressing and warn izostatic pressing. Last years in world for production of new tips of materials for cutting tools widely is used method of casting under pressure of mixture powder. For enlargement of physical-mechanical and exploitational characteristics cutting inserts are subject of mechanical working. From showed is evident that it is a question of metals and semimetals chemicals fusions from class (figure 2) [2-4,7,10]:

- oxide,
- carbide and
- nitride.

Structure of all three tips materials for cutting tools permit the forming of mixed crystals, that is permit the forming of dispersion one phase in other phase. Using such possibilities of alloying the combinations are

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possible as in frame of one tip oxides, carbides or nitrides, as and combinations of corresponding components various tips. At this way are formed the undertips: oxi-nitride, carb-oxide, carbo-nitride and carboxi-nitride. From figure 2 is easy able to recognise the structure ones tips materials for cutting tools compared to classics divisions.

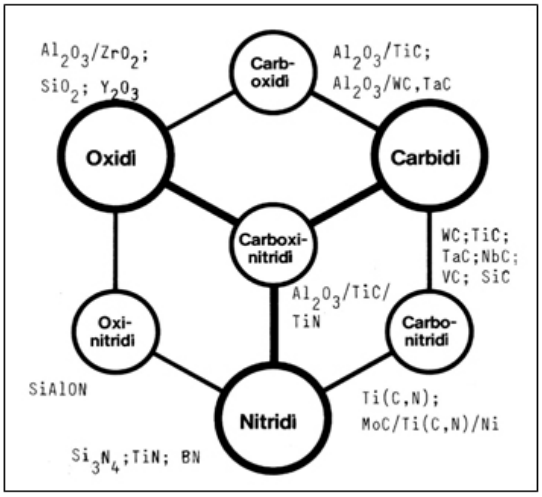

Fig. 2: *Classification of materials for cutting tools which are produced from powder various methods of sintering*

Cutting tool must have the following characteristics in order to produce good quality and economical parts:

- Hardness and strength of the cutting tool must be maintained at elevated temperatures also called hot hardness;
- Toughness of cutting tools is needed so that tools don't chip or fracture, especially during interrupted cutting operations;
- Wear resistance means the attainment of acceptable tool life before tools need to be replaced.

Basic characteristics of cutting-tool materials are shown in table 1 [9,10].

Table 1: *Basic characteristics of cutting tool materials*

Cutting-tool Material	Hardness HV 30 (N/mm²)	Temperature of steadiness tools (°C)	Solidity on pressure (N/mm²)	Solidity on bending (N/mm²)	Density (kg/dm³)	Young's modules x10³ (N/mm²)
High speed steel	7500-10000	600-800	2500-3500	2500-3800	8,0-8,8	260-300
Carbides	13000-17000	1100-1200	4000-5900	800-2200	6,0-15,0	430-630
Cutting ceramics	14000-24000	1300-1800	2500-4500	300-700	3,8-7,0	300-400
Cubic boron nitride	45000	1500	4000	600	3,45	680
Diamond	to 70000	600	3000	300	3,5	900-1000

Dependence of hot hardness and wear resistance from strength and toughness for different of tools material is shown on figure 3 [2-3.5,9-10] and speed ranges for various cutting –tool materials are shown in figure 4 [9].

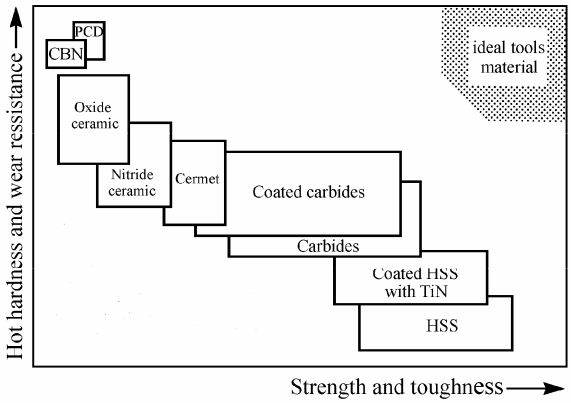

Fig. 3: *Dependence of hot hardness and wear resistance from strength and toughness for different tools material*

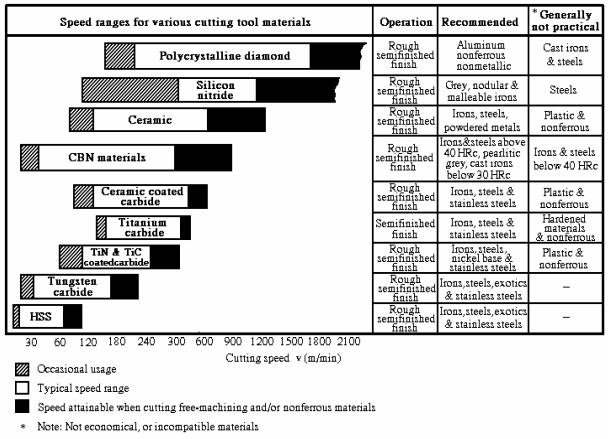

Fig. 4: *Speed ranges for various cutting–tool materials*

3. CLASSIFICATION AND CHARACTERISTICS OF CERAMIC CUTTING TOOLS

Ceramic cutting tool are made of metallic and non-metallic particles from oxide, carbide and nitride, which basic features are: high hardness, high resistance to wear and pressure, high chemical stability on high temperatures.

There are three basic groups of ceramic cutting tool materials (figure 4) [2-5,7]:

- oxide ceramic (oxides),
- mixed ceramic (oxides+carbides) and
- nitride ceramic (nitrides+oxides).

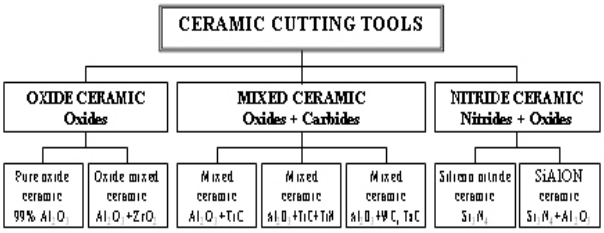

Fig. 4: *Classification of ceramic cutting tools*

Oxide ceramic applies for rough and finish off processing of cast iron and steel with high cutting speeds. Cutting tools of high speed steel and hard metal

can be changed with oxide ceramic cutting tools in turning, milling and planing.

Mixed ceramic cutting tool is suitable for rough and finish off processing by turning and milling of cast iron, steel for thermal processing, harded steel with hardness up to 65 HRC and high speed steel, too, all of them with cutting speed which is 3-6 times higher than speed of hard metal. Eliminating of drosses, sands and cavities are prerequisite for economical applying of mixed ceramic cutting tools. In last time, grinding is changed with grating finish of with the help of ceramic cutting tools in metalworking industry.

Nitride ceramic is used in branch of metal turning and milling processes on cast iron and other castings with adversely cutting conditions, with interruptions of process, with use of cooling and lubricating fluids, or with high requests for accurate dimension with medium and high cutting speeds. Use of nitride ceramic is able on machine tools with small powers which is not suitable for application of oxide ceramics. According to high prices of nitride ceramic, it applies in mass production particularly on automatic lines and flexible technological systems.

Basic characteristics of ceramic cutting-tool materials from firm SPK-Feldmuhle are shown in table 2 [1-3].

Table 2: *Basic characteristics of ceramic cutting-tool materials from firm SPK-Feldmuhle*

Grade	SN 60	SN 80	SH 1	SH 20F	SL 100	SL 200
Composite	Al_2O_3+ZrO_2 ≈90%+10%	Al_2O_3+ZrO_2 ≈80%+20%	Al_2O_3+TiC ≈90%+10%	Al_2O_3+TiC ≈80%+20%	Si_3N_4+TiC	Si_3N_4+ Al_2O_3
Colour of insert	White	while	black	black	black	black
Code colour	Blue	violet	white	yellow	green	red
Code number (=last digit of ref.no.)	…5	…4	…6	…9	…1	…2
Density [g/cm^3]	3,97	4,16	4,30	4,28	3,30	3,25
Grain size [µm]	<3	<2	<2	<2	<2	<2
E-module [KN/mm^2]	340	340	370	370	300	300
Vickers hardness HV	2.000	2.000	2.500	2.100	1.700	1.500
Breaking strength Kl_c [N/mm$^{3/2}$]	175	210	160	170	250	220
Bending strength σ_B [N/mm^2]	450	600	600	600	800	750

Ceramic cutting tools have some advantages in respect to hard metal concering the filings shape and posibility to apply higher cutting speeds. It is enough in about 80 % cases to choose the right facet of a replaceable cutting plate and vary cutting speed in order to obtain good filing shape (figure 5) [2-4].

For the remaining 20 % cases where good filing shape is not schieved, cutting tools manufacturer developed various ways for making complex-cannals on the front surface [2-4].

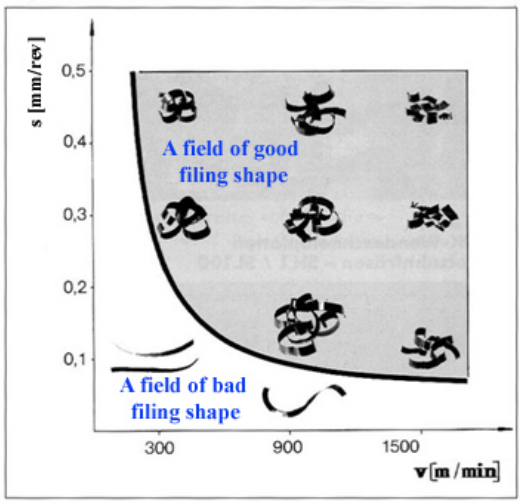

Fig. 5: *A field of good filing shape for ceramic cutting tools in v-s diagram*

4. EXAMPLES OF APPLICATIONS CERAMIC CUTTING TOOLS

Ceramic cutting tools with MCII in region of material working magnified hardness are used for finish working of improved and hardened steels by turning, planing, drilling and milling. In many cases this operations can exchange the operation of grinding.

Effectiveness of working cited ceramic cutting tools in much depend from correct chose material for cutting tools and whole structure of cutting tool. Negative effects who can to report oneself by reason of wrong choose of material for cutting tools on illustrate best by used oxide and mixed cutting ceramics at finish turning of harded steel with hardness 52÷54 HRC. By that for value of tool wear VB=0,25 mm it is tool steadiness from mixed cutting ceramics 55 min, and tool steadiness from oxide ceramics only 13 min.

Example 1: On figure 6 it is presented the operation of finishing turning of the small gear from harded steel hardness 62÷63 HRC by mixed cutting ceramics SH1 by firm SPK Feldmuhle, by which is realized by demanded roughness worked of surface R_t=8 [µm]. The elements cutting regime were: cutting depth a=0,15÷0,2 [mm], cutting speed v=100÷180 [m/min], feed s=0,08 [mm/rev] and nose radius r=1,2 [mm]. For difference from grinding, the working costs by finish turning are reduced for 25 % (fig ure 6) [3-4].

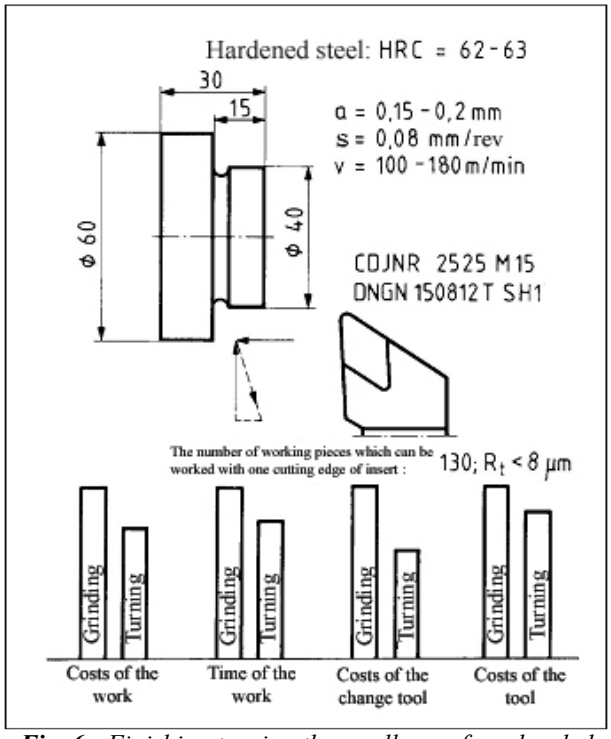

Fig. 6: *Finishing turning the small gear from harded steel hardness 62÷63 HRC with mixed cutting ceramics*

Example 2: On figure 7 it is presented the operation of finishing turning the cover from cast iron FC 20 (according to GOST standard) by nitride cutting ceramics SP4 by firm NTK Cutting Tools. The elements cutting regime were: cutting depth a=2÷3 [mm], cutting speed v=700 [m/min] and feed s=0,2 [mm/rev]. For difference from turning with oxide ceramic the number of working pieces which can be worked with one cutting edge of insert is increased for four multiply [11].

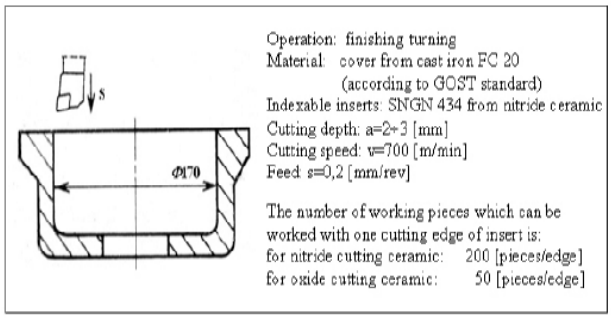

Fig. 7: *Finishing turning the cover from cast iron FC 20 with nitride cutting ceramics*

5. CONCLUSIONS

Effectiveness of working by modern ceramic cutting tools in much depend from correct chose material for cutting tool and whole structure of cutting tool.
Application of ceramic cutting tools it is possible exchange the finish operation grinding by turning, planing, drilling and milling, what show and tree examples cited.

REFERENCES

[1] *Coromant Zerspanungstechnik, Drehen,* Handbuch, Copyright Sandvik Coromant, 1985. - 203 p.
[2] Dašić P.: *Analiza mogućnosti primene reznih alata od keramike,* Zbornik radova VII Međunarodne naučno-stručne konferencije Fleksibilne tehnologije mma′2000, s. 5-6, 8. juna 2000, Novi Sad
[3] Dašić P., Ječmenica R.: *Analiza efektivnosti obrade primenom reznih alata od keramike,* časopis Tribologija u industriji (ISSN 0351-1642), Kragujevac, god. XIII (1991.) br. 2, s. 51-55
[4] Dworak U.: *SPK Schneidkeramik, Die Entwieklung zum Hochleistungs Schneidstoff fur die tagliche Praxis,* In: Referate SPK Schneidkeramik - Tage'84, Dusseldorf, 1984., p. 4-10
[5] Chneider G.: *Applied cutting tool Engineering,* Tooling&Productions, 2001. (Available on Web-site: http://toolingandproduction.com/)
[6] Кузин В. В.: *Теоретические основы повышения работоспособности керамических инструментов*, Сб. трудов «Научно-практические аспекты автоматизированного машиностроения». М. 1991 г. с. 121-122
[7] Momper J. F.: *Untersuchung zum standvermogen keramischer werkzeugschneiden beim drehen unter besonderer berucksichtigung der schneideneingriffsverhaltnisse,* dissertation, Vom Fachbereich Maschinenwesen der Universitat Kaiserslautern, 1985.
[8] Nedić B., Kuzin V. V., Ječmenica R., Popov F. V.: *Pesrpektive korišćenja reznih alata od silicijum nitridne keramike sa ciljem povećanja efektivnosti obradnih procesa,* časopis Tribologija u industriji (ISSN 0351-1642), Kragujevac, god. XVII (1995) br. 1, s. 18-27
[9] Radovanović M., Dašić P., Ječmenica R.: *Advanced cutting tool materials,* Proceedings of 2nd International Conference ″Research and Development in Mechanical Industy - RaDMI 2002″ (ISBN 86-83803-02-3 for Volume 1 in hard copy and electronic form on CD-ROM), p. 346-351, Vrnjačka Banja, Yugoslavia, 01 - 04. September 2002.
[10] Spur G. and Stoferle T.: *Handbuch der Fertigungstechnik, Spanen,* Carl Hanser Verlag, Munchen, Wien, 1980.
[11] Старков К. В., Кузин В. В.: *Инструментальное и технологическое оснашение металло-обрабатывающего производсва,* Обзорная информация ВНИИТЭМР серия 8 выпуск 5 (ISSN 0235-2818), Москва, 1988. – 60 с.
[12] Tanović Lj.: *Tehnologija proizvodnje savremenih reznih elemenata alata,* Mašinski fakultet (ISBN 86-7083-294-1), Beograd, 1997.
[13] Whitney E. D.: *Ceramic cutting tools, Materials, development and performance,* Hard Cover, 1994.

THE METHODS OF MODELLING OF ASSEMBLY SRUCTURES IN CA ENVIROMENT

G. Miodragović[1], A. Petrović[2], A. Žukovski[3]

Abstract:

Concurent Engineering and Design for Manufacturing are two basic methods for decreasing time of product realization and increasing of productivity. Concurent Engineering enables the communication between various experts in very early stages of design (i.e. a product designer and a designer of technology). Design for manufacturing does not involve only tooling, testing, maintenance, servicing, but also assembly activities, especially because assembly activities take part in product price with 40%. The methods of assembly structures` modelling in computerated enviroment are represented in this paper. When designing new and changing existing product`s components, with no changing of once established assembly structure, the significant savings are achieved using the software package Solid EDGE

***Key words**: CA modelling, assembly structure, CAD, Solid EDGE*

1. INTRODUCTION

Observing within the matter of product`s complexity, industrial production can be considered as a production of a component as a final product, or as a production of a complex product, including a production of components which are assembled in a final product.

The main function of assembling is to form, by putting together, a final product of certain features, whenas each component retains its geometrical features, that means quality features(quality of tooling surface, tolerance of shape and position, i.e.) by which product`s proper functioning is accomplished. An assembly process, which complexity depends on components` complexity, type of construction and demanded degree of integration with other processes (figure1.), includes several steps. It is very important to make a difference between a subassemblies` creating and a final assembling, which leads to product`s variants.

Creating of subassemblies represents a particular assembly operation, where one component is put together with another basic component or with a subassembly.

Final assembling enables realization of assembly constructing or final product constructing. In a process of a final product`s assembling, it does not necessarily mean that the other processes, which characterize machine tooling of components, control, adjusting and etc., are excluded. On the contrary, there is a tendency to include these processes between particular phases of assembling, especially in cases when retooling is necessary either because of the changes in construction, or because of the complexity of the assembling process itself, figure 2.

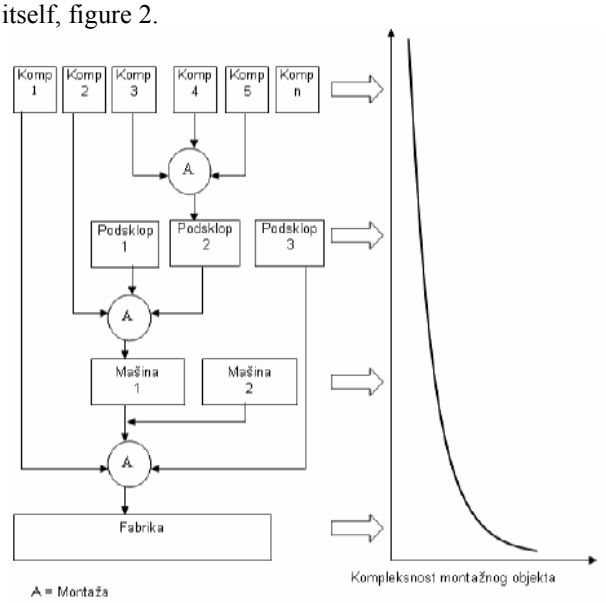

Fig 1 .Complexity assembly dependences from assembly flow

2. MODELLING FOR ASSEMBLING-DFA

When designing according to demands of assembling, a designer needs suitable tools, with which he can analize assembly process, or possible alternative solutions (of

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components, tools and equipment,…). A computer is very helpful in the sphere of appliance of particular knowledges concerning design for assembly, as well as in sphere of work with necessary data.

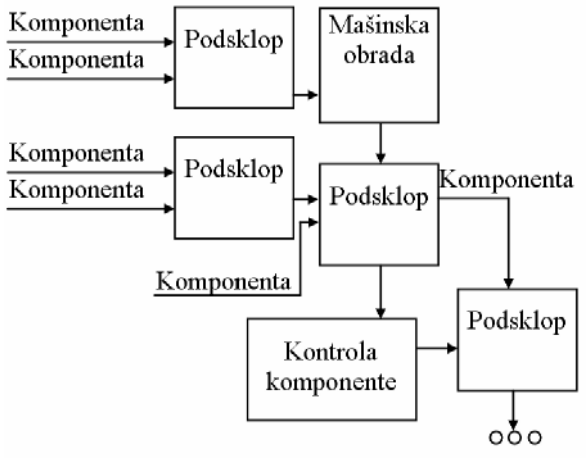


Fig. 2. Possible variant including other processes in final product assembly process

Conventional (classical) design for assembly is divided into two parts. The first part is the design of components, whenas a designer knows all about a component`s structure, including its function in product, while the latter refers to processes of assembling the designed components into a final product. Both designers are experts in their fields of design, but they know little about each other`s field of design. The solution is in parallel design for assembling and design of components and assembly process, with integrated knowledge of both designers, according to the principles and demands of concurent engineering. Such design will enable, by making a change in any stage of design of components, or in assembly process, changing in all of design`s stages concerning that change. Appliance of CA tools, represented in a form of suitable designing software, as well as a knowledge basis and a data basis, as a support to expert system in design for assembling, are necessary for achieving of this aim.

3. MODELLING OF ASSEMBLY STRUCTURE BY CA TOOLS

3.1 CA TOOLS IN DESIGN OF ASSEMBLY STRUCTURES

CA tools for design of assembly process include beside the tools for modelling of components also the tools for defining the relations among the designed components, that means the tools for defining the coincident relations (mate, coincident,…).

By joining the data basis and knowledge basis to CA tools through expert systems, enables that changes, in any stage of design of assembly (of components/process of assembling), affect the entire assembly process.

One of the most productive CA tools for modelling components&assembly is Solid Edge. This, computer-supported, system for design includes unique tools for identification and elimination of errors in design, by what the time needed for product developing and expenses are decreased.

The process of assembly structures` design(of complex product) in Solid Edge does not include only making of tridimensional virtual prototype, but also acquisition of knowledge, which leads the process of engineering design to precise solution without mistakes.

3.2. ASSEMBLY RELATIONS` MODELLING

In relation to components` modelling in constructing domain, the problem gets considerably complicated in researching the approaches and ways of modelling for assembly structure, that means elements of functions and processes.

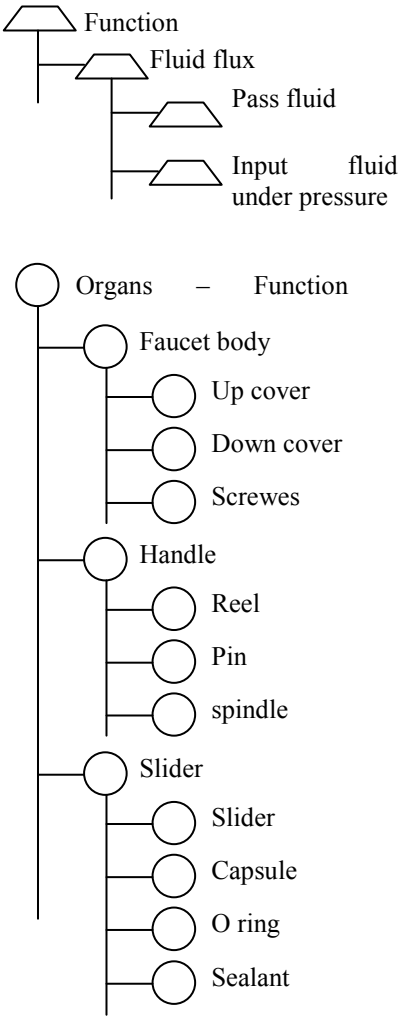


Fig 3. Function and organs-function bearers (for faucet)

In the basis of analysis of formation assembly primitives, it is started from a function of an observed assembly. It is necessary to recognize, on the basis of functional demands, the bearers of functions or the

organs for the level on which a primitive is defined (figure 3), and then to form subassembly`s or assembly`s skeleton (for faucet, figure 4).

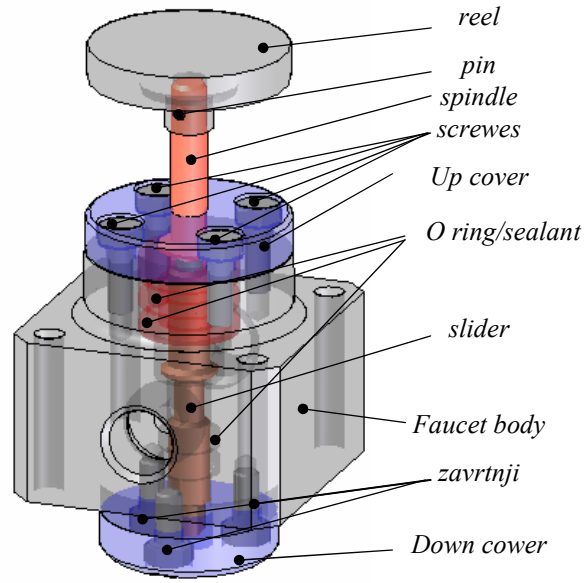
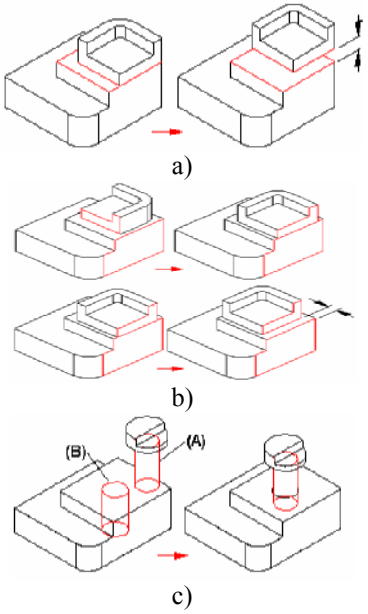


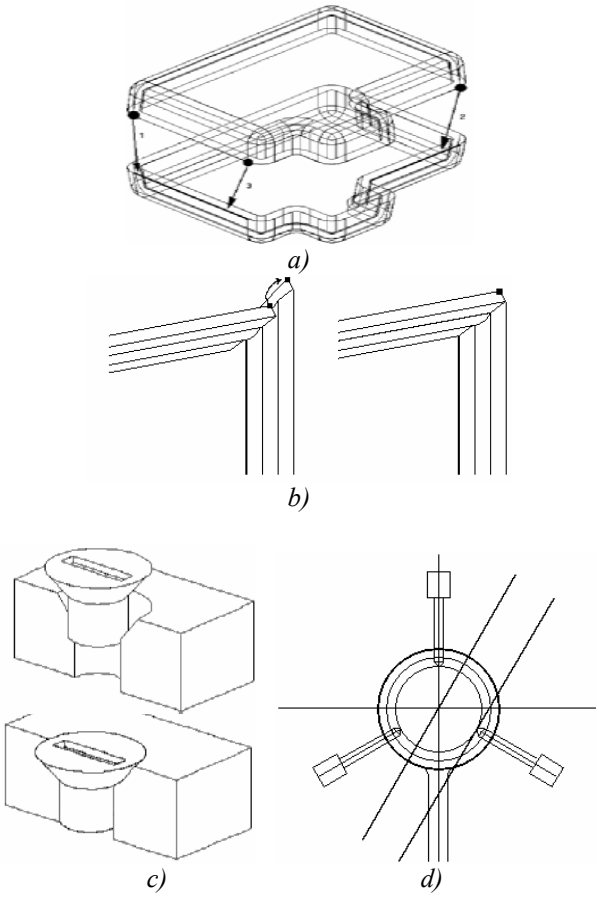
Fig. 4. Faucet for the desks for examinig the hydraulic instalations

For modelling of assembly, or for forming coincident relations between components in assembly structures, figure 3, in Solid Edge, two groups of relations are used. The first refers to establishing of "more clear" relations, or easily defined relations between flat and cylindrical surfaces (figure 5), and the latter refers to all those cases when it is impossible to establish clear relations between components (figure 6).



a) Offset-mate, b) Planar alignment between two flat surfaces c) Axial alignment between two cylindrical surfaces (A) and (B), d) Taking the certain angle between the wanted elements

Fig.5. Relations for defining of "clear" assembly primitives



a) Point-to-Line (A mate relationship is applied between the faces of the two parts. Because the sides of each part are drafted, there are no part faces which you can use to apply a planar align relationship.).

b) Point-to-Point (A mate relationship is applied between the mitered corners of the parts. A connect relationship, which ties a point on one part to the appropriate point on another, connects the two corners properly.)

c) Cone-to-Cone – (The cone on the fastener is connected to the cone on the countersunk hole on the plate. (When we add a connect relationship between two conical faces, the keypoint that represents the theoretical intersection of the individual cones are connected)

d) Point-to-Plane – (The lower right pin is positioned to a depth that just touches the surface of a reference plane).

Fig 6. Additional relations for defining of assembly primitives

4. MODELLING OF ASSEMBLY STRUCTURES

Starting from a hierarchical product`s structure, or from identification of function (providing of fluid flux), figure 7, and organs (components, figure 4) for realizing a given function, it comes to assembly model, figure 8.

Relations, or coincident components` relations are included in an assembly model.
Having established concept, an assembly structure is very easily modelled by tools for relations` establishing(given in the figures 5 and 6).

Taking into consideration a part`s function, or assembly-relational model, it is easily noticed that a basis element for forming assembly is a faucet`s body(three components are in direct coincident relation to body: upper cover, >>>>>> and lower cover). The procedure of forming an assembly structure in Solid Edge is given in the figure 9.

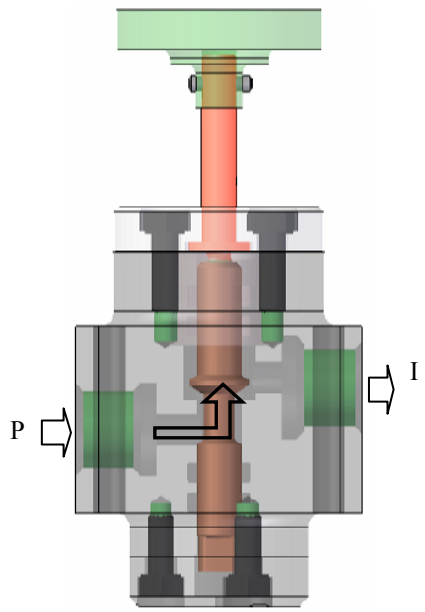


Fig 7. Fluid flux-basic faucet`s function

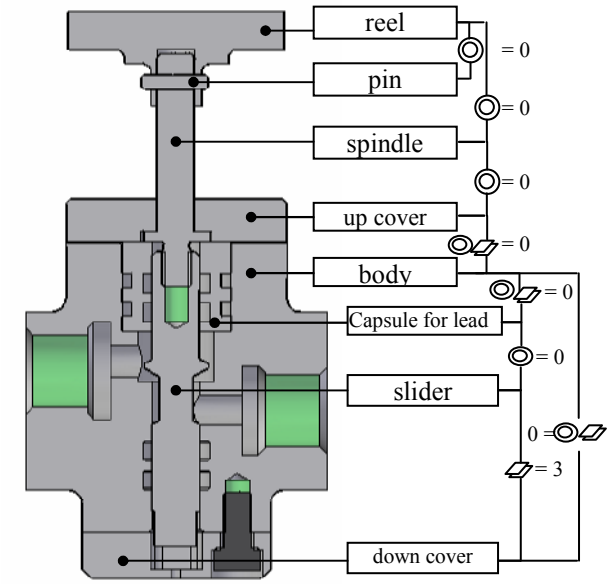
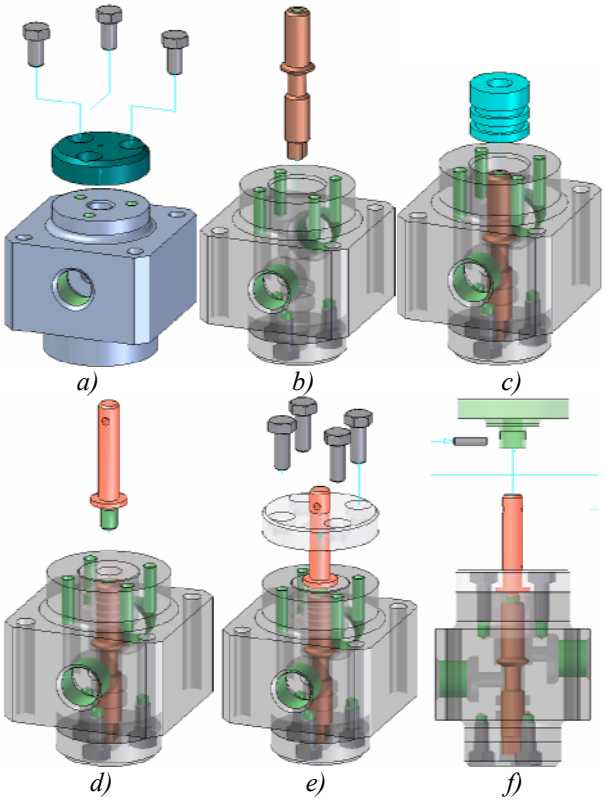


Fig 8. Assembly model with coincident relations

5. CLOSING

By appliance of CA tools in processes of assembly modelling, decrease of time and integration of a process of forming components` model and a process of assembling are achieved. Parametring components and establishing coincident relations between them, it is possible to make models of families of products. In this way a virtual model is made, on which all necessary analyses and simulation in realistic conditions can be done.



a) setting lower cover, b) interleaving slider`s, c) interleaving rein, d) link spindle, e) setting upper cover, f) link reel.

Fig 9. Process of modelling faucet`s assembly structure in Solid Edge

6. LITERATURE

1. QiangSu, Shana Shiang-Fong Smith, An Integrated Framework for Assemblz Oriented Product Design and Optimization, Journal of Industrial Technology, Vol. 19., Number 2, 2003.
2. Babić, A., G. Miodragović, Carring structure design for manufacture and assembly, The third international conference Hevy Machinery HM99, Kraljevo,1999., p. 3.73-3.77.
3. Gottipolu,R. B., Ghosh, K., Representation and selection of assembly sequences in computer aided assembly sequences in computer-aided assembly process planning, International Journal of Product Research, 35(12), pp. 3447-3465, 1997

THE UNIFICATION OF THE MECHANICAL PRESS DRIVING MECHANISM

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RESUME

The basic aim of this research is to find the possibilities of the unification of the mechanical press driving mechanism. There are certain directions and methodologies in the construction of the unified driving mechanisms in the group of mechanical presses having different pressure force and different press stroke number. A certain number of different applications are pointed considering huge number of various solutions of mechanical press driving mechanism.

The main words: driving mechanism, mechanical press, and unification.

1. THE INTRODUCTION

Considering well-known patterns and methods, we deal with the problem of finding the possibilities of application a certain driving mechanism in the group of mechanical presses whose pressure force and press stroke number are different. Selecting the flywheel and analyzing its power usage we specify the domain of its application at the presses of specified pressure force and different number of press stroke
Producing groups of presses differed by pressure force and the number of press strokes, as the main characteristics, it is possible to produce some sub-systems as unified.
The main purpose of this research is to find, through the familiar patterns, the possibility of the application of the same driving mechanism in a certain number of mechanical presses. Here, we will try to show some directions in construction of mechanical press so that the complete system (driving motor-lamella and brake-reduction gear-excentric sheave axle, and possibly presser) could be the same at a few presses of the same group (presses of different pressure force and different press stroke number).
It is obvious that this is impossible for the whole group as the range of pressure force and press stroke number is huge, but it is possible to include reasonable range (excentric sheave 63 to 100 mp pressure or excentric sheave 100 with press strokes 50-80) what gives a lot of advantages in such conditions.

This can be done if we don't stick to the principle of dimensioning machine elements considering hardness. This factor can't be completely denied or neglected, but it is just pointed that it is not always the only one and the most important, so it can be denied if other factors are economically and technically justified.
To satisfy the other factors influencing more deeply the production profitability, trying to solve this problem we had to be aware of the fact that certain press elements are more or less over capacitated.

There are some of these factors:

1. The possibility of driving system serial production for individual or small serial production directly influences the decrease of product cost..
2. Certain funds are necessary for the testing of press group as the testing of driving system and all connected with it is done only once.
3. It is easier to supply the substitute of elements and framework in usage meaning that maintenance is easier in the workshops with more presses of the same group constructed on this way.

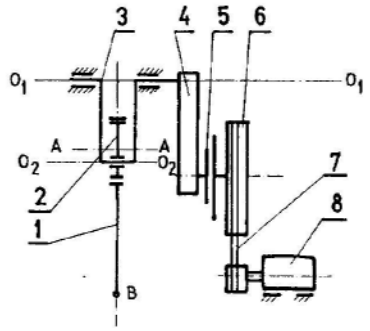

Figure 1. Universal model of mechanical curving press driving system

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2. THE DIRECTIONS FOR THE UNIFICATION OF DRIVING MECHANISM

To analyze this problem in details, we must set the scheme first consisting of elements: electric motor (8), flywheel (6), lamella and brake (5), reduction gear (4), shaft (4), connecting rod (1) and presser.
The application of certain driving system depends on the choice of flywheel.
The selection of flywheel: The selection of flywheel is made using the formula:

$$\left(GD^2\right)_m = \frac{7\cdot 10^6 \cdot P_m \cdot \lambda}{\beta \cdot n_{sm}^2 \cdot n_e \cdot S_k \cdot \left(2 - S_k\right)\cdot p} \quad [\text{daNm}^2] \quad (1)$$

where: $(GD^2)_m$ - GD^2 of flywheel is reduced on the axle of electric motor in $daNm^2$,

P_m - nominal power of driving motor in KW,

λ - Coefficient of motor overloading that is here from 1,7 to 2,2.

p - Coefficient representing the relation of real cycles to possible ones (for automatic work, p=1)

n_{sm} – Synchronized number of electric motor rotations per minute,

n_e – The press stroke number per minute,

S_k – Critical sliding of electro motor given in the formula:

$$S_k = S_H \cdot \left(\lambda + \sqrt{\lambda^2 - 1}\right) = S_H \cdot k \quad (2)$$

where:

$$S_H = \frac{n_{sm} - n_m}{n_{sm}} \quad (3)$$

- Nominal sliding of electric motor

n_m – Nominal number of electric motor rotations per minute

β - Coefficient that is the function of power coefficient γ and diagram coefficient of resistance moment α.

If we lack the data for β obtained by an experiment, we can get coefficient β by the formula:

$$\beta = 0{,}9 \cdot \sqrt{\frac{\gamma^2 - 1}{\alpha}} \quad (4)$$

where: γ - coefficient of engine power and it is usually from 1,1 to 1,3 and

α- coefficient of resistance moment which is usually from 0,5 to 1,0.

It is marked like this:

$$a = \frac{\lambda}{s_k \cdot \left(2 - s_k\right)\cdot p} \quad (5)$$

$$C_1 = a \cdot \frac{7\cdot 10^6}{n_{sn}^2} \quad (6)$$

$$C_2 = \frac{1}{\beta} = \frac{1}{0{,}9 \cdot \sqrt{\frac{\gamma^2 - 1}{\alpha}}} \quad (7)$$

equation (1) is now in following shape:

$$\left(GD^2\right)_m = C_1 \cdot C_2 \cdot \frac{P_m}{n_e} \quad [daNm^2] \quad (8)$$

Let's analyze, (5), (6) and (7):

1) The value of engine overloading coefficient (λ) is in relatively tight limits from 1,7 to 2,2 and it can be asserted that it has little influence (almost none) on the value of the formula (5), while the nominal sliding of electric motor makes the main influence (table. 1). For the burst work the value of coefficient a is given in the list T1 for, λ = 1,7 and λ = 2,2 with the practical average value.

A diagram on figure 2 is drawn according to the values on the list T 1.

2) Driving machines used for the mechanical presses are asynchronies three-phase short-circuited motors with 2, 4, 6, and 8 ends, with synchronized rotating number n_{sm} = 3000, 1500, 1000, and 750(rev/min). According to this, for all the electric motors, the burst work, it is possible to calculate the value of coefficient C_1, which is shown on the diagram and figure 3.

In the formula (7) we can see that C_2 is the function of coefficient λ i γ. Changing γ to 1,1 — 1,3 and α from 0,5 — 1,0 we get the values for C_2 as shown on the diagram in figure 4.

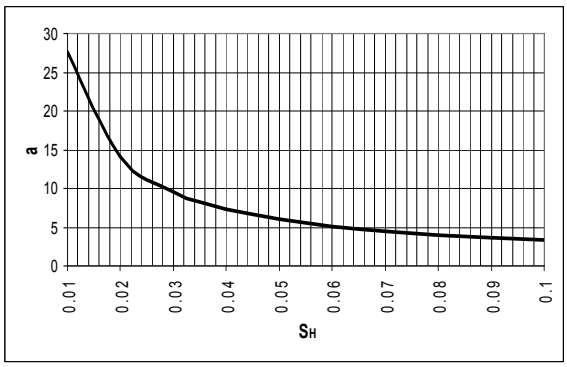

Figure 2.

It must be mentioned that nominal sliding for asynchronies three-phase short-circuited motor is not higher than 0,1.

As we defined the value of C_1 in function to S_H and C_2 in function to α and γ, we can easily define the and $(GD^2)_m$ of fly wheel using the formula (8) for the certain electric motor and press stroke number, with at first approximation supposed values for α and γ, define $(GD^2)_m$ of flywheel.

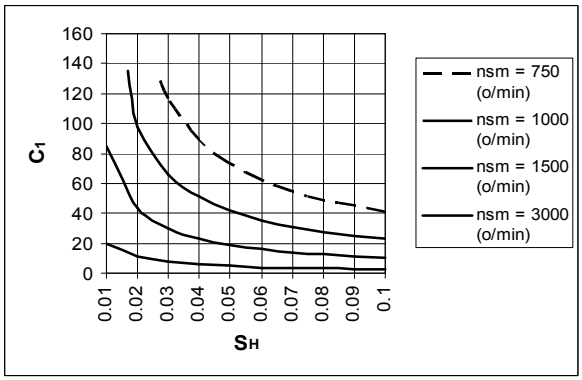

Figure 3.

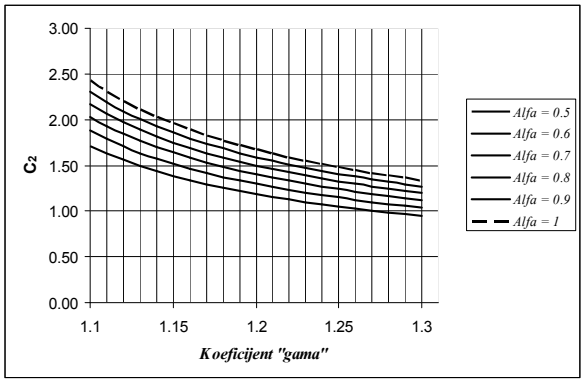

Figure 4.

Table T-1.

	a for S_H									
λ	0.10	0.09	0.08	0.07	0.06	0.05	0.04	0.03	0.02	0.01
1.7	3.28	3.57	3.95	4.43	5.10	6.00	7.40	9.65	14.3	28.1
2.2	3.34	3.61	3.97	4.44	5.04	5.91	7.23	9.40	13.8	27.0
	3.30	3.60	3.95	4.43	5.07	5.96	7.32	9.52	14.0	27.5

Defining the transmission ratio electric motor – flywheel we want, or which is suitable, considering lamella available and the dimensions we need to place the flywheel, we can easily define dimensions and weight of flywheel using the familiar formula:

$$\left(GD^2\right)_z = i_{mz}^2 \cdot \left(GD^2\right)_m \qquad (9)$$

As we defined the flywheel, we defined the lamella and the transmission ratio but reduction gear with transmission ratio, inlet and outlet rotating moments as well. In short, a mechanical press of certain possibilities is defined, and it represents a group of mechanical presses. Changing the pair of gear in redaction gear, or changing the press body and safety plates, we can get the other presses in the group with their characteristics, the presses with the other press stroke number or the other pressure force.

3. CONCLUSION

Analyzing the solution for the mechanical curving press of simple effect and analyzing its main functions we come up with a number of these machines that produce by deformation.

Analyzing the universal model of driving mechanism (without discussing its individual parts), we can identify possible concepts of variations and classify them.

We consider the solution by analyzing the laws of orbit changing and analyzing the number of work orbit cycles in working part of the machine, as these parameters are tightly connected with the solution for the driving mechanism.

The presented parameters show the complexity of finding the solution at the machines of static effect and wide range for the creativity of a constructor, which led to the large varieties of these machine types.

It is useful to consider the case of unified driving mechanism for the universal model of driving mechanism. Changing some of the components, the characteristics of the press inside the group are changed as well.

4. REFERENCES

[1] Popović P., Machines for the production by deformation (part I), Faculty of Mechanical Engineering, Nis, 1991.

[2] Popović P., Đurković A:, Contribution to the unification of mechanical press driving mechanism, Magazine “Technic” (Mechanical Engineering), Belgrade, 1965, XIV, br.10

[3] V. I. Vlasov, Krivosipnie kuznecno-pressovie masini. Teorija i proektirovanie, Moskva, 1982.

ONE APPROACH OF DEVELOPING THE NETWORK SOFTWARE USED IN CIM TECHNOLOGIES

G. Vujačić, S. Ristić, Ž. Marjanovic[1]

Monitoring presence, usability, and response times of the different host workstations on LAN or WAN networks using cross – platform, open source ICMP interface libraryICMP, cross-platform, networking, library

I PREAMBLE

Nowadays, when computer networks are growing in their organization and infrastructure complexity, it is essential to monitor presence, network characteristics, usability and data transfers between different network hardware, network servers and end user workstations, all in favor of speed, quality and finally, business.

Client – server revolution has brought many advantages and innovations; mainly it has become the epicenter and backbone of the entire network facility and also the standards implementer. There are many software products present on the market today, starting from the network simulators to the IRC or chat programs, mail clients, private intranet chat servers and various dedicated software applications. In this, so called "jungle" of software, not just server administrators, but more often, users need to know if there are remote hosts present on the network. Users want their software to be easy to use, with friendly interface and simple help files; they want software to be fast, attractive and easy to use. On the other side, server administrators want to have more control; they do not care much about the user interface, they want to tune their software to their needs and personal taste; furthermore, they want their software to be extendable, scriptable or based on the *plug-in* architecture.

So what can one computer scientists or engineer do to help?

There are many demands: portability, interface, modularity, *plug-in* architecture, easiness of use, and finally budget. Open source is the philosophy which is used in this solution; it fulfils most of the demands of this enigma.
Pretty modest IT budget and the quality of open source solutions of the large specter, force the software designer to see the big picture.
The solution presented here follows the GNU philosophy and standards of the open source community.

The entire C – GLIBC – Console – GNOME – KDE – Windows™ framework is based on this idea and RFC documents, providing the simple, yet powerful solution to the presented problems and demands.

In this solution we are going to present the most significant parts of software, concerning advantages and disadvantages between architectures, software implementations and platform differences.

II IMPLEMENTATION

Main programming language used in this project is C, both on Windows™ and Linux platforms. C is very powerful, low level language able to access raw operating system functions, which is especially important on the Linux platform.

The core of the software is dynamic (shared) library, written entirely in C and based on the *ip-utils* package (on Linux) from Mike Muss (US Army ballistics laboratory) and the Berkley University in the United States of America. This package offers many useful utilities, among which the ping program is of the most interest. This program is Linux console program which does the "standard" pinging and is invoked from the shell with `ping <options> <hostname | IP address>`. The ping utility is useful program and is used very often by network administrators; it can also be useful in shell scripts and pipes. And … that's almost all of its possibilities.

This program completely implements the ICMP protocol and uses checksum functions that calculate IP packet data and headers length, defined in RFC 793 and 1791. It was released in the early '80s and it can run on every Linux platform I had opportunity to work with.

Windows™ solution is based on the *Icmp** functions API provided by Microsoft and with *Icmp.h* and *Icmp.lib* files. These functions are *IcmpCreateFile*, *IcmpSendEcho* and *IcmpCloseHandle*. These functions are wrapped in the iphlpapi.dll and icmp.dll dynamic

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link libraries. This solution provides another library which even more simplifies the usage and implementation.

I've mentioned that the entire library is written in ANSI C on both platforms. That is the key to the power of this library. I've wrapped all the low level details in bunch of simple to use library calls including the power and the speed of the C language.

On the Linux platform this library is compiled with the GCC (GNU C Compiler) which offers superior optimization and minimum possible file size.

On the Windows™ platform I've tried the Microsoft Native C/C++ compiler and the Bloodshed Dev C++ which is based on the *Mingw* project. Microsoft's products offers more possibilities and platform integration, but the file size of Dev C++ is much smaller (as twice as small, without the shared linking). Even though, I've noticed that the Microsoft's compiler has produced more stable and less memory demanding code, so I've decided to use it (file size does not matter that much these days: 6kb with the Dev C++ and about 10k with the Microsoft's C/C++ compiler) .

The source code implementations mentioned above differ very much.

It was "easy" on the Windows platform: wrap *Icmp* functions, write a few checksums and thread handlers (because we did not want to block the calling process), and that was almost all about that.

On the Linux platform things were different. We had to use RAW sockets, realize and/or implement entire ICMP protocol in our program, realize the standard procedures, parse replies, decode errors, preserve the buffers, install the filter(s) on the socket …

Functional differences forced implementing custom functions (which were primarily needed on Linux) and centralized flow handlers.

Based on mentioned *Icmp** Windows™ functions I've implemented *icmp_init*, *icmp_send_echo_echo*, and *icmp_get_last_error* functions in the library. They behave almost like the Microsoft's functions, which was their main purpose.

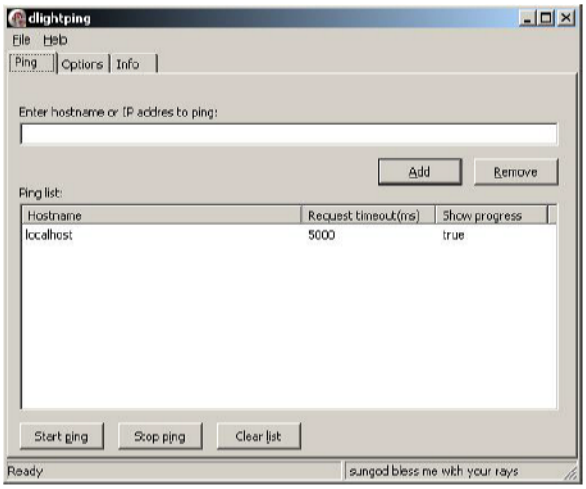
You can see the entire source code in the Appendix.

With this functions in a shared library began the GUI part of the problem.

a) Windows implementation

On Windows™, Borland Delphi having the reputation of the best RAD tool (which is true), was used to create the GUI. Delphi uses Object Pascal as its base and very powerful VCL framework. There were no major problems with creating and realizing the GUI (minor problems occurred with callback functions and redefining C structures and types). You can see the Delphi interface below. Few clicks and lines of source were just enough. Every network administrator could have done this, with the language of his choice (or even a script), because he would have the library.

Program was tested on the Windows 2000 and Windows XP and worked very stable. Its file size was a little larger, (because of the VCL) but it was compressed with UPX.



Picture 1 Delphi interface

The situation was much more complicated on Linux. First of all there are several window managers. Most popular managers nowadays are GNOME and KDE so I've decided to write interfaces for both of them, and, of course, the console version of the program.

GNOME and KDE use completely different APIs on top of the X Window Library, or so called Xlib.

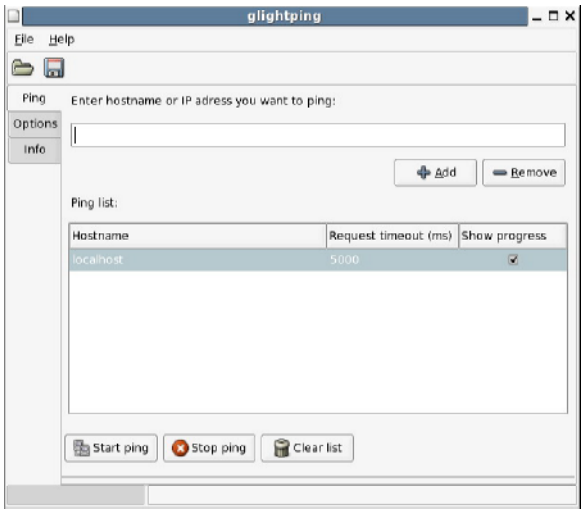
b) GNOME implementation

GNOME was built on top of the GTK+ (or GIMP Toolkit) which is completely written in C. GTK is based on the GLIB library which implements and redefines some GLIBC functions and types and gives easier and friendlier API.

Luckily there is a great tool, Anjuta IDE. GNOME implementation was completely written in it. Interface designer Glade was used to produce an UI.

Program supports GNU *gettext* package by which it can easily be translated to any language. Main source file contains the callbacks which are triggered when user interacts with the UI. New thread is created per entry, just like in Windows. Maximum number of threads that can be created is 100 per process. This limitation was set because we did not want to create to resource demanding program and to produce bugs that are hard to

trace. Lightping library was implemented as a shared library. All functions in the library are called from the thread's core stack. When the thread starts new window opens and shows the progress, as well as the TTL and round trip times. This window can be hidden (useful when there are many hosts in the list) and user can change its background and foreground colors. User can choose to automatically end running threads on exit, save and/or reload last used list on startup and to define how main times to send echo requests. Program is small and versatile and its beta version was very stable on the GNOME 2.6 platform from the SuSE 9.2 Professional distribution, as well as on the Debian Unstable Sid 3.0.1.



Picture 2 GNOME Interface

c) KDE implementation

With KDE there is different approach. KDE is based on the Trolltech Qt library and has been built on top of it. Qt library was written in C++ and has wide range of classes; from low level and utility classes to widget and interface parts of various kinds.

KDE application was developed using one of the best IDEs I have ever worked with – KDevelop. The interface part was designed with Qt Designer from Trolltech. It was easier to implement it than with Glade, and SIGNAL → SLOT mechanism is easier to use and understand then the GTK+ callbacks, (one has to write fewer lines of source code thanks to the `uic` compiler).

The only thing I do not like is Qt Designer's implementing of slots. One have to subclass the *.ui.h file to get the actual implementation of the signal handlers and the *.cpp file which can be compiled (it's not that annoying once you get used to it).
KDE application can be translated easily to (it uses i18n function versus to GTK _ macro).

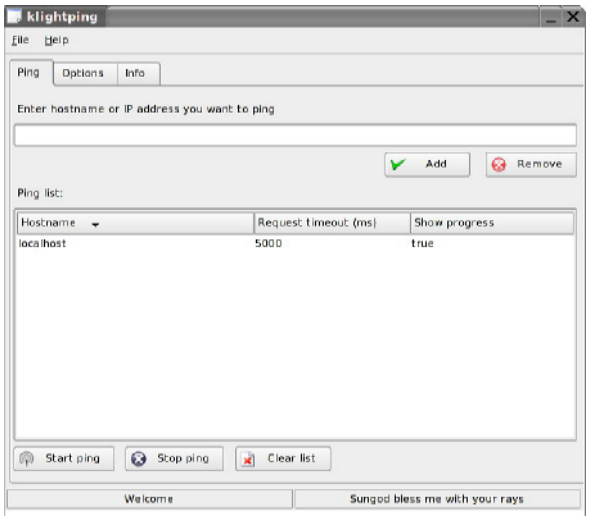
KDE applications look nicer, and can be really an eye candy, because of the superior rendering engine and presence of many window styles and themes.

There are two main source files. First one contains KMainWindow class and defines it. The second one contains implementation of the central widget (all actual work gets done here).

Similar to GNOME application, new thread is created per entry and maximum number of threads per process is 100. User can choose whether to show ping progress and other useful options. When the thread start progress window pops up and shows progress. When entire pinging process is done report is created and displayed showing TTL, and round trip times.

Ping list can be saved or retrieved from a file, which is very useful if user wants to check hosts or his local area network, or his other favorite host list.

Program is a bit more larger then the GNOME implementation it haven't crashed so far and has been tested on KDE 3.3 and KDE 3.4 from the SuSE 9.2 Professional distribution, as well as on the Debian Unstable Sid 3.0.1.



Picture 3 KDE Interface

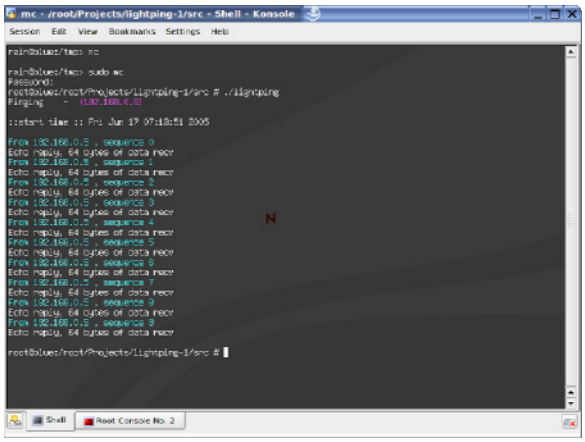
d) Console implementation

Console implementation was the easiest part of the implementation.

Program was written in C in ViM editor and compiled with GCC, linking the ligthping library. Only problem which existed was passing long list of hosts which were going to be checked on the command line. This problem was solved by the means of implementing a pipe (forking the parent process), so one can easily write a command `cat ./myhostlist > lightping`.

Of course this program has the smallest file size, because it has no UI, it is very fast and convenient to be used in shell scripts. It worked very stable and had a few

minor bugs that were successfully fixed. It was tested on the SuSE 9.2 and Debian Unstable Sid 3.0.1.



Picture 4 Console implementation

III DEPLOYMENT AND VARIOUS CHARACTERISTICS

Even though this projects is open source it has some limitations depending on the interface implementation used:

- On the windows platform it is because of the Delphi, which is not free tool; it is commercial software licensed from Borland Corporation.
- On the KDE platform GPL + Qt license apply (basically Qt license is free for the open source programs).
- On the GTK/GNOME platform program is completely under the GPL.

Every platform has some advantages and disadvantages. To be able to run a program one must have root permission or have the program installed as suid root on the Linux platform. This is because of the raw sockets. There is no such limitation on Windows; every standard user account can be used to run the program.

On Windows Icmp functions are implemented in the icmp.dll library and can not be used for fine-tuning and reimplementation.

Furthermore GTK framework does not allow program to have setuid root. If this is the case GTK refuses to initialize and quits. I've solved this using a pipe as a mean of transferring data from the library and backwards.

There are installation problems (on Linux platform), too.

If you are trying to compile the library in the GNOME environment you need to have libgnome, libkeyring and libgtk2 development packages, as well as other GNOME development files.

For KDE application to compile you need Qt version 3.3 and above and at least KDE 3.3

There are no special requirements on the Windows platform, but I'm not sure how this library works on the Win9x.

Library itself and console application do not have any special requirements, they have been successfully compiled on both platforms and have been thoroughly and heavily tested.

This library is just a part of another, larger software project which is currently under development and will have ICMP functions library as a plug-in module.

This project is primarily developed for the Linux platform, following the Open source philosophy.

LITERATURE

- http://www.ietf.org/**rfc**/
- http://www.faqs.org/**rfcs**/
- http://packages.debian.org/stable/net/**iputils**-ping/
- http://www.novell.com/products/linuxpackages/professional/iputils.html

NONLINEARITY IN FINITE ELEMENT ANALYSIS[1]

M. Popovic, M. Kalajdzic[2]

Abstract

This paper presents some of the principles of nonlinear analysis, and gives example of contact analysis of an assembly. In general there are three major, and most common, sources of nonlinear structural behavior: geometric nonlinearity (large scale deformations, large strains, snap-through buckling), material nonlinearity (plasticity, creep, viscoelasticity) and boundary condition nonlinearity (opening/closing of gaps, contact, follower force). In a contact analysis, the relation between the load applied to the model and the resulting deformations and stresses is not linear. The contact area changes nonlinearly as the load increases, because the contact area depends on the deformation of the model. Nonlinear FEA allows one to simulate the behavior of the product and based on the information obtained from the simulation, to apply engineering judgment to optimize the design.

Keywords*: Finite element analysis, Nonlinearity, Contact*

1. INTRODUCTION

Analysis in structural or mechanical engineering means the application of an acceptable analytical procedure based on engineering principles. Analysis is used to verify the structural, thermal, or other multi-physical integrity of a design. Sometimes, for simple structures, this can be done by using handbook formulas or other closed form solutions. More often, however, this type of analysis relates to complex components or structural assemblies and is performed by using computational simulation.

The predominant type of engineering software used in these analyses is based on the Finite Element (FE) method, giving rise to the commonly used term Finite Element Analysis (FEA). Over the past 50 years, FEA has been successfully applied in all major industries, including: aerospace, automotive, energy, manufacturing, chemical, electronics, consumer, and medical industries. FEA is indeed one of the major breakthroughs of modern computational design engineering.

This paper presents some of the principles of nonlinear analysis, and gives example of contact analysis of an assembly.

2. THE CHARACTERISTICS OF NONLINEARITY

Nature is nonlinear. Although, for our own understanding, we often look to simplify the world that surrounds us, ultimately we need to come to terms with the fact that nature and hence engineering science is inherently nonlinear, either due to material or geometry effects or other multi-physics characteristics. With the increase of hardware capacity and software improvements in the last decade, the linearization of real life engineering problems is no longer necessary, and more and more virtual simulations are being performed using nonlinear techniques. Automotive, aerospace, marine/naval, defense, construction, biomedical and packaging are just some of the industries where nonlinear techniques are used at the moment [3].

In general there are three major, and most common, sources of nonlinear structural behaviour:

Geometric Nonlinearity (large deformations, large strains, snap-through buckling). Structures whose stiffness is dependant on the displacement which they may undergo are termed geometrically nonlinear.

Material Nonlinearity (plasticity, creep, viscoelasticity). Material Nonlinearity refers to the ability for a material to exhibit a nonlinear stress-strain (constitutive) response.

Boundary Condition Nonlinearity (opening/closing of gaps, contact, follower force). Early FE analyses were typically performed on single structural components which underwent relatively small displacements. However, when considering either highly flexible components, or structural assemblies comprising multiple components, progressive displacement gives rise to the possibility of either self or component-to-component contact. This characterizes to a specific class of geometrically nonlinear effects known collectively as boundary condition or 'contact' nonlinearity. In boundary condition nonlinearity the stiffness of the structure or assembly may change (considerably) when two or more parts either contact or separate from initial contact. Examples include bolted connections, toothed

gears, and different forms of sealing or closing mechanisms.

Contact

Since the detection of contact (or separation) is dependent on a continual monitoring of an updated geometry configuration, contact is by nature a type of geometric nonlinearity. However it is often referred to as boundary condition nonlinearity since the change in contact conditions act in a similar way to changes in boundary conditions such as loads or constraints.
During contact, mechanical loads, and perhaps thermal or other physical entities, are transmitted across the area of contact. If friction is present, shear forces are also transmitted.

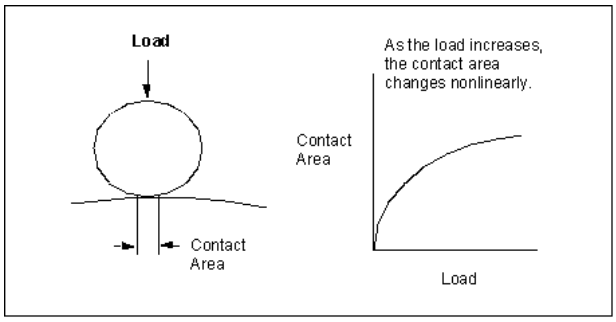


Figure 1. The contact area changes nonlinearly as the load increases

3. WHAT FEA SOFTWARE CAN OFFER?

At the Faculty of Mechanical Engineering in Belgrade two Computer Aided software are used: Pro/Engineer (include modul for FEA Pro/Mechanica) and Catia which offer gateway for FEA modul MSC.Marc. Some possibilities of this FEA software regarding nonlinearity have been presented briefly in this chapter.
There are two nonlinear cases of static analysis in Pro/Mechanica wildfire. Nonlinear means that there is an iteration process to arrive at the solution. Nonlinear analyses take longer to solve than linear analyses. The two cases of nonlinear static analysis are Large Deformation and Contact.
Large Deformation
In the case of large deformation, the stiffness matrix is recalculated as the part deforms. A large deformation analysis is necessary when model bends to the point where small deflection theory becomes invalid. Small deflection theory becomes invalid when the model bends beyond 5 degrees. It is also referred to as geometric nonlinear analysis. To check whether a large deformation analysis is necessary, you can first run a linear static analysis and inspect the deformed shape in the results. Using simple trigonometry, calculate the angle of deflection from the constraint to the farthest point in your model. If it is equal to or exceeds 5 degrees, then rerun the analysis using large deformation.
Contact
In a contact analysis, the relation between the load applied to the model and the resulting deformations and stresses is not linear. The contact area changes nonlinearly as the load increases, because the contact area depends on the deformation of the model:
Contact analysis takes longer to run than linear static analysis because Pro/MECHANICA must calculate results several times iteratively.
A contact analysis is required when two parts of an assembly are pressed together, or when a part is shaped such that is can be pressed together to the point that two surfaces will touch (Figure 2).

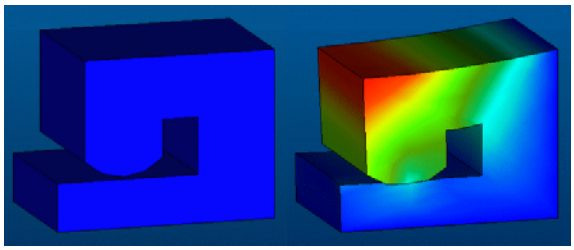


Figure 2. Example of contact analysis [4]

Contact analyses are especially useful when dealing with assemblies. The applied loads on an individual part in an assembly might be difficult to determine because the load is determined by its mating parts. So rather than trying to guess what load to apply to an individual part, you might want to place that part in the assembly, and do an analysis on the assembly. There are four important aspects of contact analysis in Pro/Mechanica wildfire: all parts in assembly must be constrained against rigid-body motion, contact regions are frictionless, contracting surfaces may be initially overlapping or coincident and contact analyses are only valid for small deflection theory (rotations less than 5 degrees).

Nonlinear Structural Analysis in Catia V5 includes gateways for MSC.Marc with geometric, material and contract analysis types.

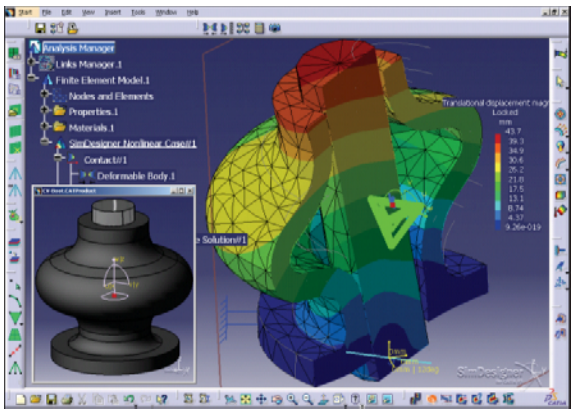


Figure 3. Large deformation and self-contact analysis on a rubber bushing [3]

MSC.Marc supports large deflections, nonlinear materials and contact (including surface to surface contact) conditions, regular and modified Newton Raphson, updated and total Lagrangian, large rotations, line search option and automatic time stepping.

In MSC.Marc, areas of potential contact do neither need to be known nor specified prior to the analysis. Potentially contacting surfaces are continually monitored, and the contact and separation conditions are automatically applied, transferring load (or other entities) accordingly.

4. EXAMPLE OF CONTACT ANALYSIS IN PRO/MECHANICA

This distributive assembly comprises a distributive clamp, two toggles which grip insulated neutral messenger and a stainless steel handle connecting this assembly to bracket (Figure 4). Modeling, nonlinear static stress analysis and optimization of distributive clamp have been applied in integrated mode of Pro/Engineer and Pro/Mechanica software (Pro/Mechanica also can worked in independent mode).
Concerning symmetry plane of distributive assembly model applied, all calculations have been conducted on one half of assembly model. Symmetry constraint consists of fixing translation normal to the plane for solid models. Figure 5 shows finite element model of distributive assembly. This model has 4170 solid elements.
Toggle part model has been exposed to the force of 15000/2= 7500 N in longitude direction. Displacements of the clamp part model are known. at the handle to clamp connection points. The model applied has two contact pairs.
The clamp is made of aluminium alloy. Mechanical features have been presented in Table 1.

Rm (N/mm^2)	140-220
Rp 0.2 (N/mm^2)	80-140
A5 (%)	2-6
HB	45-60
E (kN/mm^2)	65-75
μ	0.3
ρ (kg/m^3)	2790

Values used for simulations are as follows:
ρ = 2.7e-09 t/mm^3,
E = 69000 N/mm^2 i

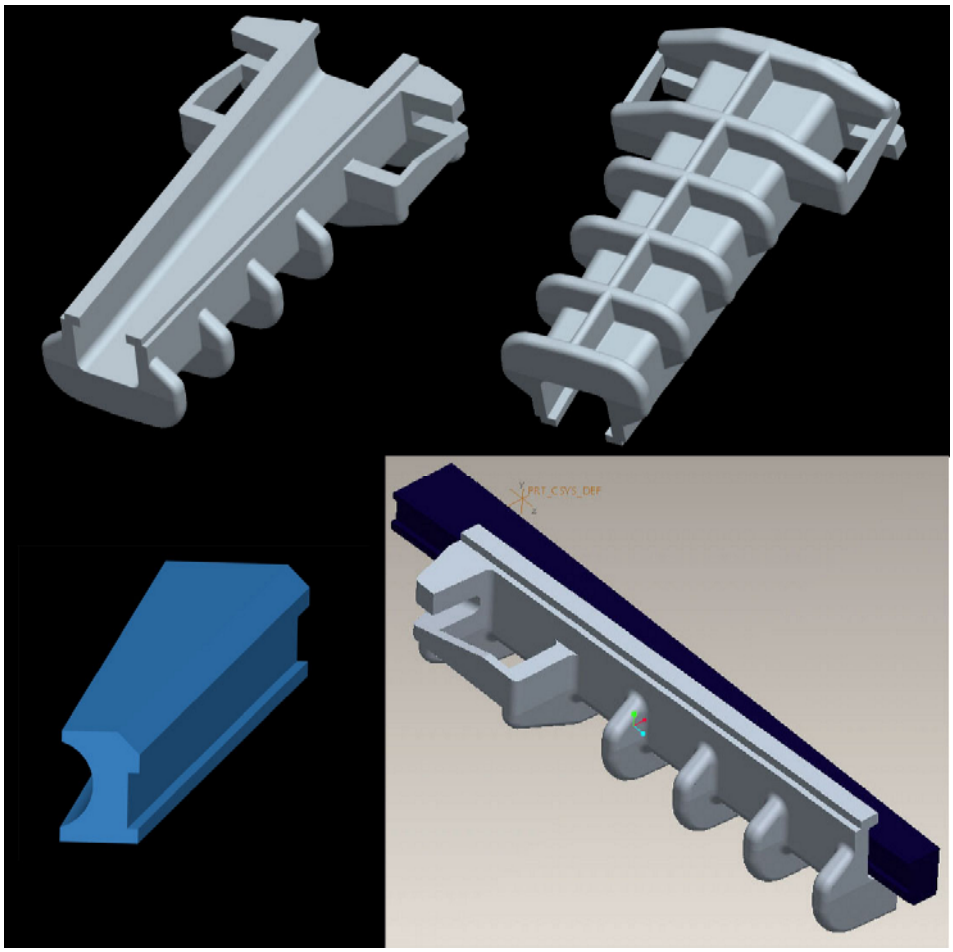


Figure 4. Distributive clamp (top), toggle (bottom-left) and a half model of distributive assembly (bottom-right)

μ = 0.3
The toggle part is made of PVC.

Distribution of von-Mises stress have been presented in Fig.6.

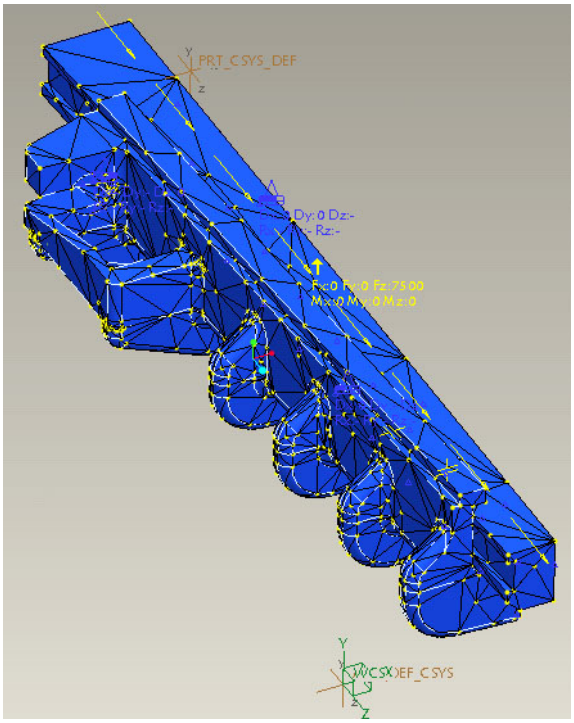


Figure 5. Finite element model of distributive assembly (1 – distributive clamp, 2 – toggle)

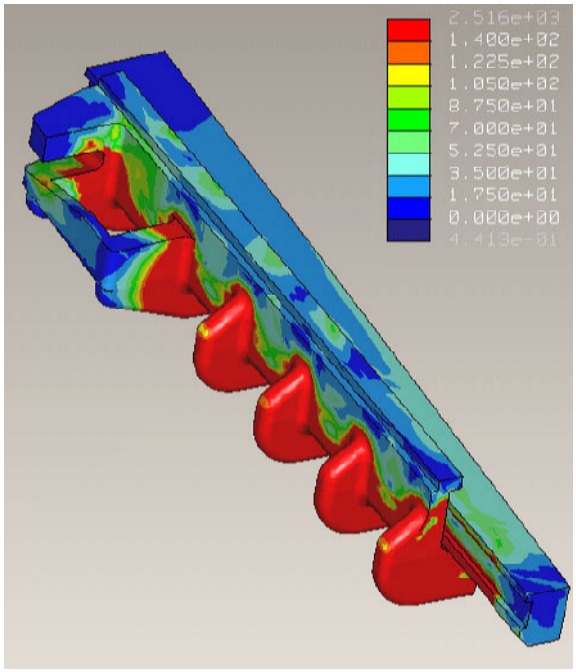


Figure 6. Distribution of von-Mises stress

5. CONCLUSIONS

Nonlinear FEA allows you to simulate the behavior of ones product and based on the information obtained from the simulation, to apply engineering judgment to optimize the design. To summarize, some of the advantages of this enhanced design process achieved:

- Improved performance and quality of finished product
- Verification of designs before prototyping
- Elimination of costly manufacturing iterations
- Reduced material waste
- Reduced time-to-market
- Competitive advantage over competitors

6. REFERENCES

[1] Kalajdžić M., *Metod konačnih elemenata, osnovi statike, statika nosećih struktura, dinamika nosećih struktura, primene*, IAMA, Beograd, 1978

[2] Sekulović, M., *Metod konačnih elemenata*, Građevinska knjiga, Beograd, 1988

[3] www.mscsoftware.com

[4] www.ptc.com

[5] Spyrakos, C. C., *Finite Element Modeling in Engineering Practice*, West Virginia University Press, Morgantown, WV

[6] Kalajdžić, M., *MEKELBA III, Metod Konačnih elemenata u BASIC-u*, Građevinska knjiga, Beograd, 1990

[7] Popovic, M., A Contribution to Development of Press Brake Frames Design and Optimization Method, Master of Science thesis, Belgrade, 2001

RELIABILITY EVALUATION USED FOR THE REDESIGN OF THE ELECTROSPINDLE IN A CNC TOOL MACHINE

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Abstract:

The main objective of this research is to show how a reliability statistical analysis of damaged components can be profitably used for the redesign of a CNC woodworking machine. The reliability analysis was performed using a self-made Monte Carlo software, based on advanced reliability methodologies and algorithms. Failure data, provided either by the original suppliers of machine's parts or by using failure information recorded by the inner service team of the Company (SCM Group), were elaborated with simulated information about life conditions (f. ex. effective working hours and days, stress condition and so on) and the effective running machines (for. ex. sales and dismissed machines).
In this way, also following a high level theoretical background, a quick and practical method for reliability analysis is developed, tested and suitable evaluated for applications: first of others, the redesign of components to improve quality.

***Keywords**: reliability, redesign for quality, Montecarlo simulation, wookworking machin*

INTRODUCTION.

Customer Satisfaction is one of the most important aspect of modern market where the needs for any Brand is to obtain the maximum satisfaction of costumers thanks to a never ending improvement of products and processes. This result is possible only if the Company knows and controls, in detail, not only every phase related to the production and sale, but, also, the way to use (and disuse) its products by customers. Every Company is able to redesign a product or a process for improving performances, decreasing, at the same time, costs. But few of them can *objectively* evaluate the quality level of their products and often occurs that basic information like the number of failures and spare parts, the costs cover by warranty, are estimated without any rational methodology, sometimes following inconsistent opinions of fortune-tellers.

Fig. 1, Woodworking machine

Aims and scopes

The main object of this research is to show how a reliability "post-mortem" analysis of faults on damaged components and subsystems of a CNC woodworking machine can be profitably used for the redesign the tool machine.
Joining various kind of information like

1. time to failures and type of defects (data coming directly from costumers by a constant monitoring);
2. conditions of life, use and disuse of the tool machines (data coming from costumers by a statistical analysis);

by a Monte Carlo simulation software, it is possible to define the reliability behaviour of the components referring to the main failure causes.

For the fundamental components or subsystems could be possible to emphasize, for example:

1. the failure causes with their relative incidence
2. the reliability behaviour at the beginning of life
3. the reliability trend at the end of life

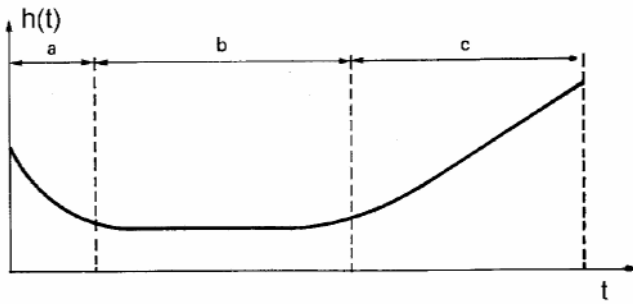

Fig. 2, Ideal failure rate for mechanical components

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The knowledge of the relative incidence of failures helps designers to clearly direct their actions where any improvement will obtain better results.
A low reliability at the beginning of life (components fail after few cycles of work) will indicate problems in the industrial process that cannot be resolve by improvement of product without considering the particularities of process.
The trend of reliability curves after an high number of working cycles can be also used to evaluate the e
fficacy of improvements before acting them. For example, a curve of unreliability that slowly increases will suggest a slowly degradation of performance that can be prevented with partial solutions (oil, paints).
On the opposite, a steep growth of unreliability will indicate that the component have reached its end limit of endurance and it is necessity to completely change the product searching for new solutions.

System
Although the study was performed over the entire CNC woodworking machine, the present paper will focus only on the CNC electrospindle, Power 2000 HSK63F of 11 kW.
This limitation appears more acceptable by the following considerations:

1. a complete reliability study for a whole tool machine would be too detailed (involving dozens of components and thousands of failure causes) without adding further interesting information on respect of the study of its more representative subsystems;
2. the electrospindle represents the most important subsystem of the machine either for complexity or for cost (15% of whole cost, the highest partial cost without considering the frame);
3. more than 50% of failures was referred to this particular subsystem (another 20% of failures referred to the load/unload subsystem and it is object of another parallel study);
4. the most part of the other not described subsystems are commercial devices or components and the Company have not the possibility to directly redesign them

This electrospindle is characterized by an high level of performance in cutting power (11 kW starting from 9.000 rounds per minute), robustness, working precision (ten times more then other similar tool) and reliability. At the same time, it is a complex subsystem at the risk of fault for different failure causes.

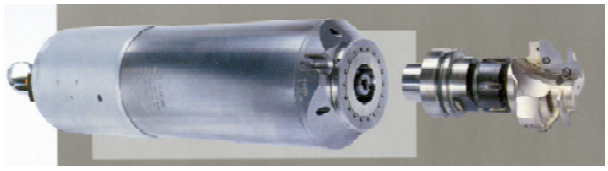

Fig. 3, CNC electrospindle, Power 2000 HSK63F

Between 30/01/2000 and 30/06/2004 the Company sold about 1.800 of these components starting to monitor each information coming from costumers.

Data and information.
Input data and useful information can be divided in:

1. information about the global system:
   - ⇒ trend of sales
   - ⇒ time limit for dismissing (or obsolescence)

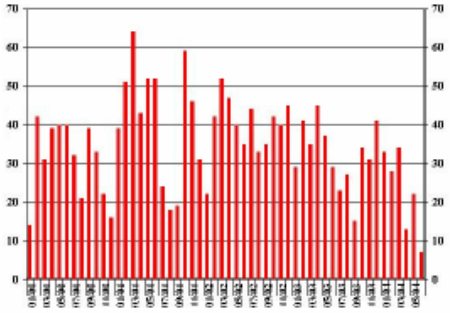

Fig. 4 , Trend of sales

2. information about working conditions:
   - ⇒ stress conditions during the operative cycle
   - ⇒ number of operative cycles for an hours
   - ⇒ effective working hours for a day,
   - ⇒ effective working days for a month,

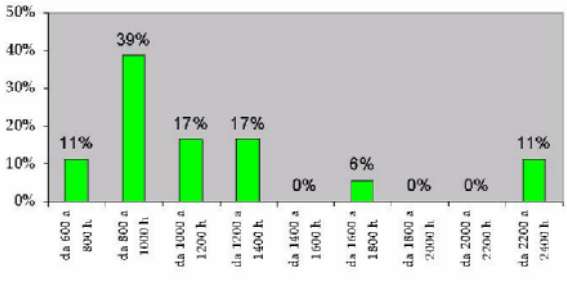

Fig. 5, Global density of utilization (it probabilistically takes in count of different working conditions)

3. information about failures
   - ⇒ working time before the first failure
   - ⇒ failure cause
   - ⇒ maintenance policy

Information was provided either by the inner design and service teams of the Company (SCM Group) or by a direct contact with the customers.
After 54 months, between the 1800 monitored machines, they reported 148 failures, divided in 17 different causes. Then, failure causes were grouped in:

1. mechanical (bearings, tongs, pistons)
2. pneumatic (membranes, valves, water)
3. electronic (sensors, processors)
4. miscellaneous (other causes)

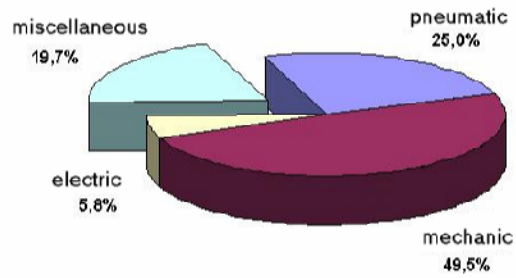

Fig. 6, Repartition of failures between failure causes

Calculation Methods.

Calculations were performed in different steps:

1. analysis of draft data and Monte Carlo simulation of the working system (by self-made codes) to obtain the reliability empirical curves
2. extrapolation of reliability models from empirical curves (using a commercial software tool)
3. new Monte Carlo simulation (by self-made codes) to obtain the complete knowledge of the system.

Monte Carlo algorithms are often used to foresee a complex system's response by the stochastic simulation of every different situation in which the system could evolve [4]; each modification of this simulated system represents *a single story,* a possible evolution, while the global response can be obtained by combining the parameters of single story's response.

first step: "not-parametric" estimation

The reliability analysis was performed using a self-made Monte Carlo software (LifePrev®), based on advanced reliability methodologies and algorithms.
Using sale data and working condition information a simulation was done to obtain the *aging profile* of components: practically a density curve with the fraction of tool machines (on Y-axis) that has reached a specific number of working hours (in X-axis) in a particular *calendar date*.

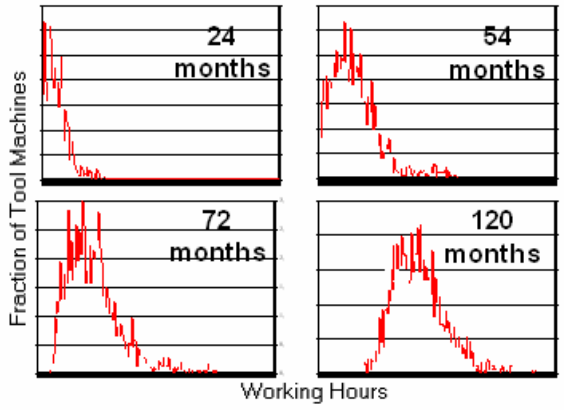

Fig. 7 "aging profiles" after 24, 54, 72, 120 months

Comparing the registered failure data with the aging profile for the same calendar time of recording, it was possible to obtain an *unreliability curve*: practically a density probabilistic curve with the fraction of fault machines (on Y-axis) that stochastically had a failure before reaching a specific number of working hours (in X-axis). The unreliability function was estimated using Herald-Johnson or Kaplan-Meier *not-parametric estimators*, as theoretically defined in [1].
Not parametric estimation of reliability basically means that the estimation is done without preventively considering a particular reliability or physical behaviour of component, but only taking in count of draft data. Not parametric estimation is very useful for a quick vision of the problem, but show strong limits for further and more detailed investigation.

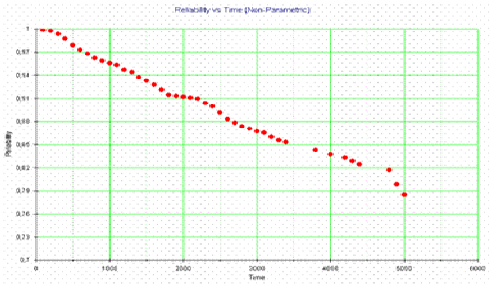

Fig. 8, reliability curve with not parametric estimator

second step: "parametric" estimator

Thanks to not-parametric draft estimation and using a commercial software tool for statistical analysis (Weibull^{++}), it was possible to obtain a parametric evaluation of component's reliability. Proper algorithms suggested criteria to choose the best approximation between widespread models and mathematic formulations. Practically it was possible to move from discrete curves of failure probability to analytical models able to describe the physical behaviour of failing components for each failure cause.
Referring to the whole component and without dividing by different failure causes, it was possible to evaluate that after 1.200 working hours (a period approximately equivalent to one year of a typical activities), 6 electrospindles on 100 have been broken and repaired. At the second year, the number is double; the third year, the number is three times and this proportional growth continues till the fifth year (about 6.000 hours, and 78% or reliability) when reliability curve start to decrease faster. After 15.000 hours of working, about 12 years, the probability for a electrospindle to be broken would reach and overcome the probability to continue to work, but customers will not discover this loss of quality because obsolescence for this kind of tool machine is consider to be less than 10 years.

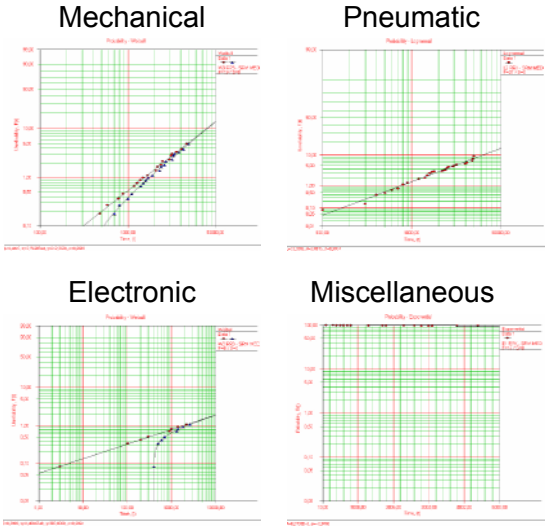

Fig. 9, unreliability models of fault (show in proper charts) for each of failure causes.

third step: complete simulation

As in the first step of calculation, the last phase of simulation used sale data and working condition

information to obtain the *like-real* aging profile of components. But, at the same time, Monte Carlo algorithms used failure data, by extrapolated models, for the evaluation of reliability response of the system.
In this way it was possible to estimate the trend of failures (or spare parts) for the whole component and related of each failure cause. The number of failures will linearly increase of about 3.5% for year till 2008 (27.8%) when a the saturation will start to show its effect. This information can be easily used for planning the maintenance service and the spare part storage.

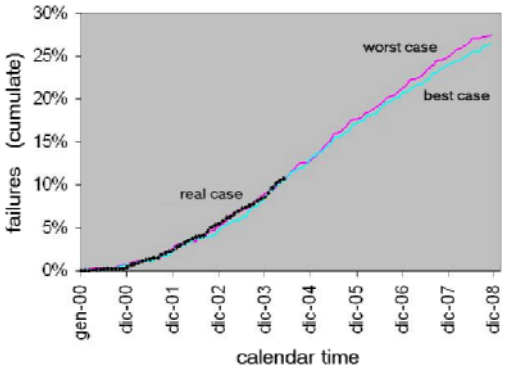

Fig. 10, Comparison of real and simulated failure trends for the whole component (all failure causes)

Redesign for Quality.
Observing the reliability curves and the best fitting models it was possible to obtain useful information to direct the task of designers for the quality improvement of the component. Separately considering each failure cause:
Mechanic failures: with an incidence of about 50% (mean value considering the entire life cycle of component) they represent the most common failure cause: wear bearings, broken tongs and problems with pistons, etc. The quality of whole component is heavy influenced by its mechanical reliability. A *three parameter Weibull model* appears the best choice for expounding this behaviour. The related statistical function is a versatile threshold function able to describe various physical situation. In particular, this model is a proper choice in the case of a "chain system with a weak link": the resistance of the whole chain is the resistance of its weakest link.
Pneumatic failures: with an incidence of about 25% they represent a large group of failure cause: no correct positioning of members and valves, closure of pipes and passages, loss of refrigerant and water, etc. A *Lognormal model* appears to expound this aspect. The lognormal function is used to represent a situation of a "multiplicative global effect of random local effects" like ageing, fatigue phenomena where the functionality depends on external actions that proportionally reduce.
Electronic failures: not working sensors and electronic devices appear to follow a *Weibull model* against the theoretical background that suggest an Exponential model. This was related to the presence of a deep relation between electronic and mechanic subsystems (electronic devices that drive mechanic systems).
Miscellaneous failures: even if their high incidence (about 25%), the *Exponential model* clearly shows their complete random way of emerging.

Failure Cause	Reliabilty Model	Reliability at 4500 h	Mean Time to Failure
All	Weibull 3	0.812	21700 h
Mechanics	Weibull 3	0.986	>> working life
Pnematic	Lognormal	0,927	>> working life
Electronic	Weibull 3	0,957	34 100 h
Miscellaneous	Exponential	0.954	>> working life

CONCLUSIONS

Following a high level theoretical background, a quick and practical method for reliability analysis is developed, tested and suitable evaluated for different applications: first of others the redesign for quality of components and system.
By reliability, new useful information for redesign can be acquired like, in this case, the following conclusions

⇒ mechanical failures are less important than pneumatic in the first thousands hours of working (2% against 5% after 3 year): so it would be better if any task to improve the quality in warranty period first moved to solve pneumatic faults;
⇒ mechanical failures become strongly dominant after 5-8 years: any improvement on mechanics will mainly reduce utilization costs for costumers;
⇒ electronic failures can not be sharply reduced without considering the mechanical problems;
⇒ although their high incidence, miscellaneous failures appear too random and inhomogeneous for a serious task of redesign for prevention

REFERENCES.

1. Meeker W. Q., Escobar L. A., "*Statistical Methods for Reliability Data*", J. Wiley, NY, 1998. [2] Hollander M.,
2. Wolfe D. A., "*Non parametric statistical methods*", J. Wiley, NY, 1999.
3. Birolini, A. "Reliability Engineering – 3rd Edition", Springer, 2003
4. Dubi A., "Montecarlo applications in System Engineering", Wiley, England, 2000.
5. Bathe K., Owen D., "Reliability of Methods for Engineering Analysis", Pineridge Press, 1986.
6. Bury K., "*Statistical Distributions in Engineering*", Cambridge University Press, 1999.
7. BSC, *Formal-FTA Manual*, July 2002.
8. RAC, "Nonelectronic Parts Reliability Data", 1995.
9. Fragassa, C., Morelli P., Zucchelli A., Massimo S., "Studio affidabilistico e previsionale per un sistema elettromeccanico di utilizzo automobilistico", AIAS 2002 – Parma

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implementation of the research methodology on their systems.

PREVENTIVE MAINTENANCE OF MECHANICAL SCISSORS USED IN METAL PROCESSING INDUSTRY

Viara Pozhidaeva[1], Dragan Živković[2], Milorad Rančić[3]

Abstract:

In this work, the principles of the preventive maintenance of the mechanical scissors are being considered in order to reduce the number of malfunctions as well as the increase of the production capacity. Both work analysis and tracking of type and cause of mechanical scissors malfunction have been carried out in the sections of the AMI (Agricultural machine industry) "Zmaj". The results of the research have been presented in this work.

Key words *: preventive maintenance, mechanical scissors*

1. INTRODUCTION

Production process requires all available production capacity and transportation equipment to be functional, in other words , as intensive use of production and transportation equipment as possible. During the use of the production and transportation equipment , the material becomes old and technological and working efficiency is also reduced. Besides that, there is a manifestation of malfunction, damage, crash and all the other ways of stoppage and breaks during work. The work stoppages cause the manifestation of additional expenses during replacement and repair of parts as well as expenses because of stoppage in the process of production which was caused by waiting the production equipment to be repaired.

Industrial scissors do not belong to the group of expensive transportation means, therefore , there should not be production stoppages because of their malfunction. In order to reach this level, it is extremely important to maintain them as best as possible, to reduce the possibility of their malfunction. Statistic analyses show this production equipment capacity to be reduced for approximately 3.47% (hydraulic scissors), actually 4.6 % (mechanical scissors) because of the malfunction.

2. INDUSTRIAL SCISSORS

Scissors are used in industrial sections and metal processing workshops and their purpose is to cut all sorts of tin of thickness up to 7 mm , of strength from 25 to 90 kp/mm ^{2} depending on the thickness of the tin which is cut. Apart from cutting of tin boards, endless tin strips can be cut as well. The precision of the boards cut is +0.1mm per one meter .Owing to a great number of working operations of the knife, scissors are very productive and convenient to be put into assembly lines for tin processing.

Scissors can be shown as:
- mechanical scissors (*picture 1*)
- hydraulic scissors

The basic scissor characteristics are:
- Cutting boards of irregular outlines according to previously marked lines is available
- The upper knife is under the angle of 3° which releases tin during the process of cutting. The knives have been made with more (four) cutting blades.
- Clearance between the knives is mainly set by moving the table manually.
- Lubrication is central and separate
- Tin weights are separate

In case of cutting tin which is stronger than nominal, following formula can be applied:

$$D_1 = D\,(R / R_1)^{1/2}$$

where :

D_1 is- required tin thickness in mm
D is – nominal tin thickness in mm
R is - nominal tin strength in kp/mm^2
R1 is- given tin strength in kp/mm2

3. PREVENTIVE MAINTENANCE OF MECHANICAL SCISSORS

Preventive maintenance of mechanical scissors include the following check-ups:
- Inspection of screws and stencils. In case they are loose, to tighten them
- Inspection if all working surfaces have been

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lubricated
- Inspection of belt tension
- Inspection of knives
- Clearance set up
- Keeping scissors clean

If we want to divide preventive maintenance according to the place of maintenance of mechanical scissors, we have:
- preventive maintenance of elecricity
- preventive maintenance of mechanical elements
- lubrication of mechanical scissors

Preventive maintenance of electricity

Mechanical scissors are set into action by means of electric motor with rotor in the form of a cage and of which the engine housing is closed. The electric motor is connected to the grid by means of tripolar switch which is controled by pressing buttons.The electric motor is protected from overburdening with tripolar thermometer which must be set to the area which corresponds to the engine current specified on the plate.
- Preventive maintenance of electric wiring should be carried out once a month.If necessary , clean and replace. Also,check the protection wiring.
- General condition of the electric equipment (wiring) should be examined every six months.It is also necessary to examine if the thermic relay is functional. If the relays during overburdening of elecrtic current do not separate the motor from the grid in one minute, they should be set or replaced with new ones.
- Electric motor should be dismantled and dusted from inside and also examine the insulation once a year. Bearings should be cleaned and relubricated using fresh grease.

Preventive maintenance of mechanical elements

Preventive maintenance of mechanical elements includes periodical examination of mechanism condition.Particular attention should be paid to control and brake mechanisms.

During preventive examination of mechanical scissors it is necessary to examine the condition of knives. Work with a blunt or incomplete knife is not allowed.

All operations connected to the setting or lubrication are to be carried out before the machine is set into action.

In case of any kind of malfunction during work, scissors are to be shut down.

Lubrication

For mechanical scissors, central lubrication, oil bath as well a separate lubrication are mainly applied .

Central lubrication, which is done by means of circular oil (M-120 viscosity of 50° C from 10.6 to 13 E), includes the following elements of the mechanical scissors:
- Left and right bearing of the main shaft
- Left off-centred part
- Link
- Left and right beam extention
- Left and right inclined reign of the support
- Left and right straight reign

With pump for grease lubrication the following elements of the mechanical scissors are lubricated:
- Bearing of the spindle on the limiter (if necessary)
- Supporter of the fly-wheel (after every replacement of the fuse)
- Brake lever (after every 8 hours of work)

The following elements of the mechanical scissors are lubricated by spraying or oil bathed :
- Roller bearing
- Cog-wheels of the machine
- Off-centered part
- Bearing socket
- Rotary pin

When lubricate spraying, actually oil bathing, oil should be added up to the mark on the oil sensor.

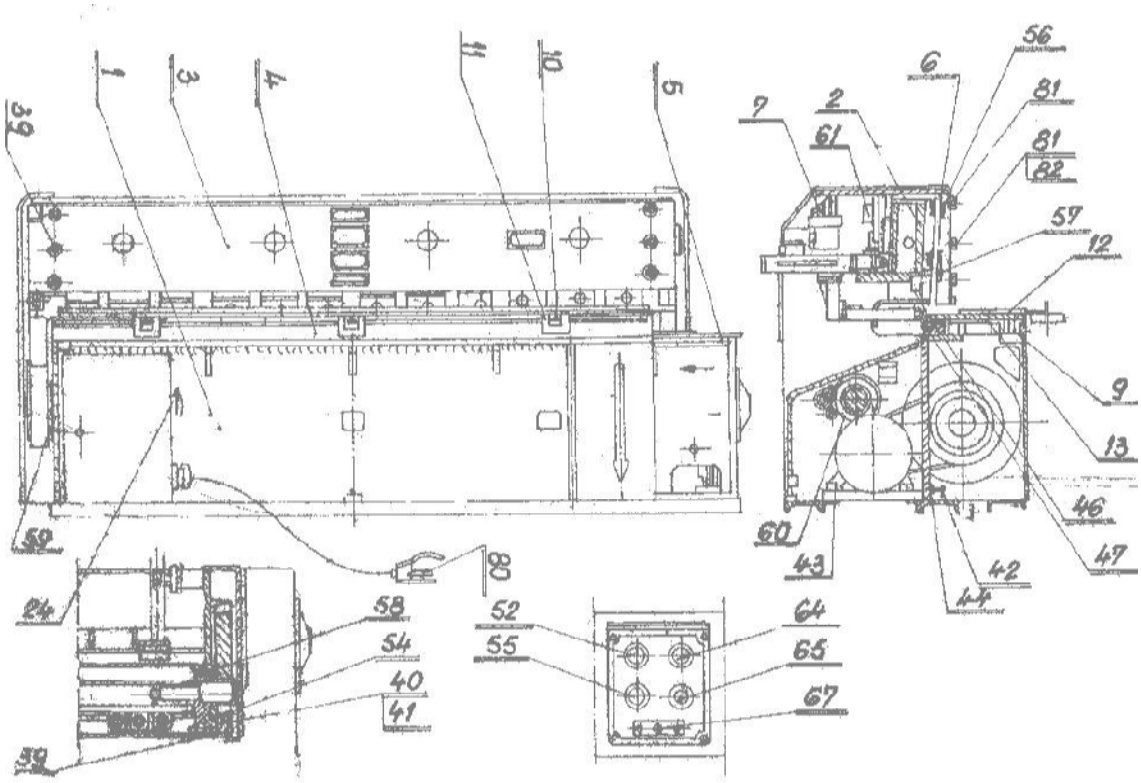
During the period control ,the old grease should be removed and after the scissors have been cleaned, all the parts are to be lubricated using new grease.

4. RESEARCH RESULTS

In the factory (AMI) “Zmaj”, in the machine section there are 6 mechanical scissors with the following characteristics:
- Allowed thickness of the tin which is cut (with strength of 50 kg/mm^2) 5mm
- Maximal length of the cut 2500mm
- Angle of the cut 1° 30
- The number of working operations in a minute 50
- Main motor power 7.50KW
- Mechanical scissors weight 4350 kg
- Mechanical scissors dimansions 1200 x 2070 x 1370mm

On the average, these mechanical scissors do not work 80 hours in a year.This is because mechanical scissors wear out (on the average they last for 38 years). Statistic tracking shows that the malfunctions are divided into :
- Electric malfunction 8 hours
- Mechanical malfunction 68 hours
- Lubrication 4 hours

Starting from the fact that the possible capacity of the



Picture 1 : Schematic description of mechanical scissors

(1- machine body; 2- knife support ; 3- frontal clamp ; 4- table; 5- reductor cover; 6-wieght; 7- rear limiter ; 8- knife segment, 9,13 – screw; 10- console ; 11- scale ; 12-cornerer; 24- head of the switch; 25- fly-wheel ; 26- fuse ; 27- shaft; 28- main shaft; 29-off-centred part ; 30-pulling lever; 31- rotary pin; 32- rotary pin socket; 33- brake; 34- pulling line ; 35 – electromagnetic lifter ; 36 switch-off button ; 37- fuse cover ; 38,40,44,46,48,74 – screw-nut; 39,41,42,43,47,51 – screw ; 49,50,68 – bearing ; 52,55,64,65 –control buttons ; 53 –reigns ; 54,58 – sliding reigns; 56,57,73 – socket ; 59,60,62,75,76 – bearing socket ; 61 – control panel ; 63 – ring ; 66,70,72,81,83 – spring ; 67 – switch ; 69 – substitutor ; 71 – frictional panelling ; 77 – revolving container of the brake ; 80 – foot switch ; 85 – wedge-shaped belt)

factory of agricultural machines » Zmaj« during one shift is 1725 hours per a year, we have been observing work during both shifts,with the total number of working hours of 3450 hours per a year (it is 365 days - 52weeks – 8 days of public holidays – 20 days of annual holiday) x 7.5 hours per a shift x 2 shifts = 230 x 15 = 3450 hours per a year), we get the result that one mechanical scissors during one year , when used in both shifts,do not work 2.3 % (4.6 % when they are used only in one shift).

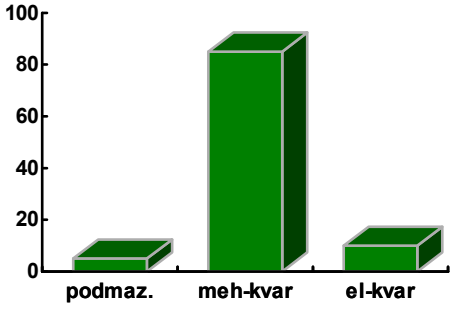
Recorded average annual stoppage of the mechanical scissors is divided into the following types of malfunctions expressed in percentages:

- Lubrication 5%
- Mechanical malfunctions 85%
- Electrical malfunctions 10 %

The usual reason for the intervention on mechanical scissors is because of the belt damage, knife supporter damage, lever crash or cog –wheel crash or actually wearing out in the activating system.

Apart from relativly little time during which the mechanical scissors«do not function », this time can be reduced even more by better preventive maintenance, actually better preventive maintenance organisation.

Or if we express it in the form of a diagram we get the following pictures 2:



Picture 2: The percentage of the malfunction type for mechanical scissors

Operational availability includes the time of the usage and the time of the stoppage of the system.Average operational availability can be determined by the application of this formula:

Pro = tk / (tk + tz)

Pro = 1645 / (1645 +80) = 0.9536

Table 1.

The name of the equipment	Maintenance duration in 2001. (hours per a year)	Maintenance duration in 2002(hours per a year)	Maintenance duration in 2003 (hours per a year)	Maintenance average duration (hours per a year)	Number of observed scissors (pieces)
The mechanical scissors	522	498	420	480	6
The average of one scissors	87	83	70	80	
Availability	0.9496	0.9519	0.9594	0.9536	
Maintenance mark		-0.0023	-0.0075		

Where :

Pro is – operation availability

Tk is =1645 (hours per a year) – the time of the usage

Tz 80 = (hours per a year) – the time of the stoppage

From table 1 it can be seen that the maintenance time during the first and the second year of observation is the mark of the maintenance :

Ood = P (t1) – P (t2)

Ood = 0.9496 -0.9519 = -0.0023

Where :

Ood is – the mark of the maintenance success between two time periods t1 and t 2

P (t1) – production equipment availability in a time period t1

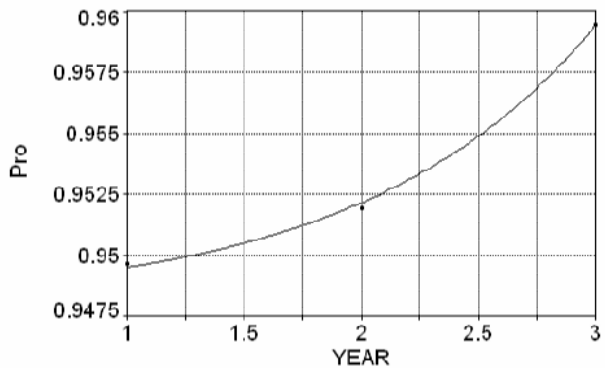
P (t2)-production equipment availability in a time period t2

It is obvious that the maintenance quality is better in every year. If the results from table 1 are shown in the form of a diagram we get the curve which can be approximately the same as the curve shown in the picture 5. and the equation of which is:

$$Y = 1 / (a+bx)$$

Where the parameters of the equation are:

a = 1.0549 and b = -0.000625



Picture 3 :Mechanical scissors operational availability during the observation time

In picture 3 it is possible to see that from the start of the system quality application in maintenance, we get the increased level of their liability.

5. CONCLUSION

Regardless the stoppage time periods which may happen using the mechanical machines (the analysis in the AMI » Zmaj« shows that it is 80 hours a year, actually 2,3% of the total possible capacity,in one working shift), this time can be reduced by better preventive maintenance and its better organisation.The effort of any kind directed towards making production process cheaper is useful at all events.

6. BIBLIOGRAPHY

1. Živković D., Gemalje(1998), Horysontal drill – milling machines lubrication , OMO, No 4,Belgrade , pp.176 -183.

EUROPEAN APPROACH TO PRODUCT CONFORMITY ASSESSMENT

Dr Mirko Đapić, Dr Vladimir Zeljković[1]

Abstract:

This paper[2] representing a general approach to the product conformity assessment for the product on European Union market. The product in global depends to (1) mandatory certification defined in New and Global Approach or (2) voluntary certification defined through various certification systems.

***Key words**: Conformity Assessment, New Approach, Certification Systems*

1. INTRODUCTION

The requirements for products that could be ready and satisfy European Union market depends whether on technical legislation of New Approach or not.

If the products in frame of technical legislation than the product conformity assessment are defined in eight modules due to Council Decision of European Union for product conformity assessment.

The numbers of these products are in spectrum from 20% to 25% of total ones which are delivered to the European market. (Prešern, 2005). These products pass through so called "mandatory" procedures of conformity. As a verification of successful implementation of the procedure the manufacturer is liable to put a CE mark on his product, and that means an acknowledgement of conformity with essential safety demands defined in adequate Directives.

If the product are not implied in technical legislation of New Approach than it belongs to so called "voluntary" verification. Hence in other words it means that the manufacturer is open to choose certification or not to certify a product. The manufacturers used to do the certification in aim to get customers and as an objective to create a market advantage to competition. The size of different systems of certifications could be large. ISO book (ISO 1992) gives eight different systems of third party certification for products.

The purpose of this paper is to represent a global approach to product conformity assessment for the products that are delivered to European Union market.

2. NEW AND GLOBAL APPROACH

Free flow of goods, services, people and money is the foundation of common market. The aim is to:

> *Dismantle a technical barriers from inner EU market as consequences of **national** technical regulations, use of national standards and established test procedures, control and product certification.*

A mechanism which enables the realization of this goal is based on:

- prevention from new market barriers,
- mutual recognition and
- technical harmonization

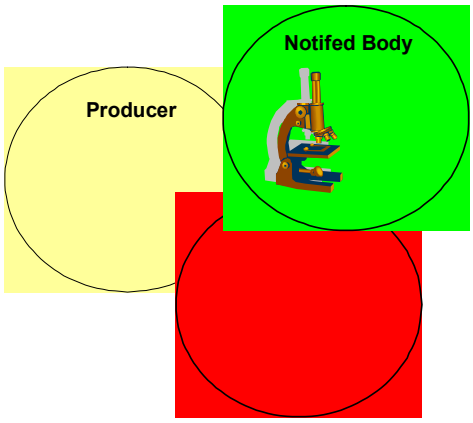


Figure 2.1 Main participants for providing a technical legislation

When we speaks of New and Global approach than we must to identify a main actors for implementation of technical legislation of European Union level (Figure 2.1). There are:

- **Manufacturer**
  The one who produce a product or authorized represent. He is responsible in general for

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[2] In this paper there are some parts of research framed in project TD-7082B, "Development and application of methods and procedures of testing, control and certification of machine tool and high pressure vessels according to European directives" which is partly finance by Ministry of Republic of Serbia

conformity of its product according to essential requirements defined in directives of New Approach. The simplest way to do it is through use European harmonized standards.

- **Notified body**
  Notified body is the institution for evaluation of conformity which officiate the tests, inspection and certification of products and QMS if the directives of New Approach requires involvement a third party. Those must be independent and objective respectively to all parties prior to producer and market supervision.

- **Market surveillance authorized body**
  Agreeable force criterion including market supervision are indispensable assuring a right implementation of New Approach directives.

Main elements of New Approach (Fig 2.2) defined in Council Resolution[3] of New Approach technical harmonization and standardization section. Those are:

- To assure high level protection of mutual interest such as health, security, consumer and environment protection for manufacturers and their authorized represents in EU there are defined a mandatory essential requirements. There are defined in such way that is unique to apply in whole EU. Such an approach enable Conformity Assessment Bodies (CAB) to evaluate a conformity of product according to essential requirements, and institutions for development of European standards (CEN, CENELEC and ETS) to develop a standards regarding particular or complete accomplishment of essential requirements.

- Manufacturers are free to choose any technical solution regarding essential requirements. The products that matched harmonized standards are in assumption correlated to essential requirements.

- Manufacturers are in obligatory to select adequate procedure of conformity which must be according with a type of risk related to product. Reciprocal, these procedures require an involvement of conformity assessment body as a third party. These bodies are known as notified bodies which the member states sign in to European commission for services of test, inspection and QMS and products certification that are liable to technical jurisdiction of New Approach. Manufacturers are loose to select the most promising procedure for conformity assessment according to demands of appropriate directive (appropriate annex of directive).

- Manufacturers or their approved represents are liable (in the most directives of New Approach) prior to releasing a product to the market sign a product with CE. This sign carry the information that the product conforms regarding all harmonized standards, apropos that the product "pass" all the required procedures of conformity assessment. As the acknowledgment of all this on the product is applied CE mark.

- Responsibility of the members states is to attempt appropriate criterions of obligations including market surveillance in order to remove the products from market if the ones do not satisfy the essential requirements of directives and not pass all the conformity assessment procedures respectively.

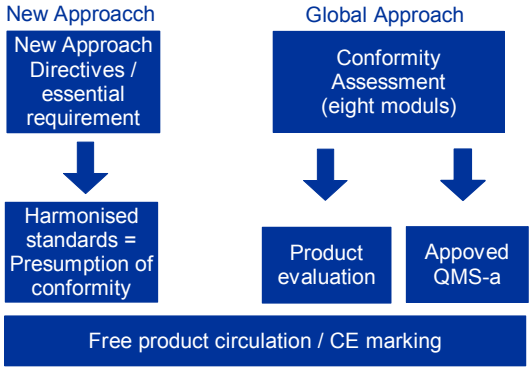


Figure 2.2 New and Global Approach

Shortly, the foundations of New Approach are based on:

- Product conformity prior to market

  Products that are placed to the market must accomplish essential requirements. Manufacturer provide this marking CE sign on a product

- Product control on the market

Member states must control the market products according to the essential requirements. This aim is due to national agency for market surveillance

3. EUROPEAN APPROACH TO PRODUCT CONFORMITY ASSESSMENT

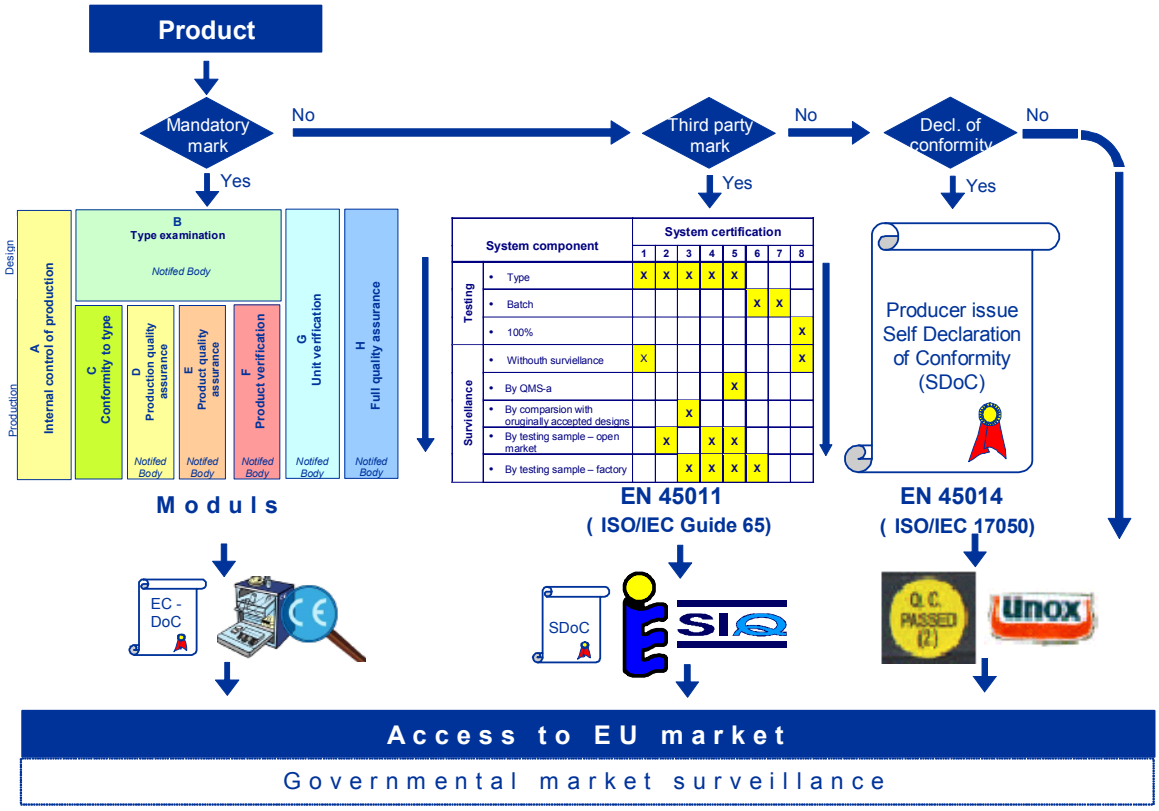
There are a different ways for placing products to the European Union market. The manufacturers and suppliers use diverse techniques which very often involve engagement an independent body third party for conformity assessment of the product.

The picture 3.1 gives an overview concerning the main routes for mandatory or voluntary routes for product conformity assessment.

Required first answer is the products in frame of or not in technical legislation of New Approach.

If the product pertains to technical legislation, namely closed by directives of New Approach, the procedures of

[3] 93/465/EEC: Council Decision of 22 July 1993



Figer 3.1 Eoropean approach to product conformity assessment

conformity assessment are defined in Council Decision[4] of European Union as introduction of conformity assessment modules.

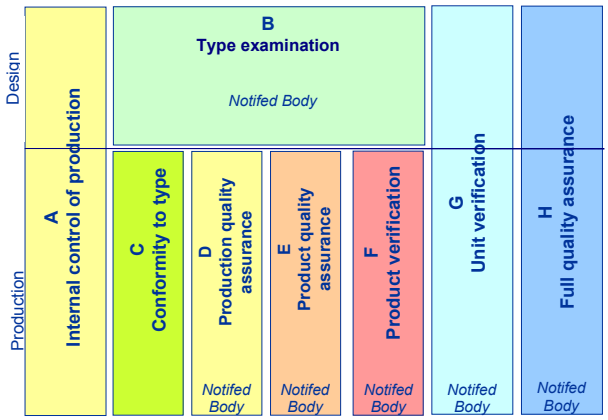


Figure 3.2 Modules of mandatory certification

Procedures of conformity assessment included in directives are based on modules for conformity assessment (Figure 3.2). Variety of modules, require from producer to include an independent third party in the procedure of conformity assessment, notified bodies respectively. Engagements of these bodies are principally required in procedures of conformity assessment which are related to high risk products hazardous to the people health and environment. Hence it is very important that those bodies act own function with prior valid high level of competence, integrity and professionalism. The obligation of the member states is to nominate those bodies if they have demand from market. In other words, member states have not obligation to nominate the bodies for all directives then only ones that have a demand from market or interest.

The nomination of bodies for assessment of conformity is an obligation according to directives of New Approach and the criterions are in Council Decision No EU 93/465/EEC about introduction of conformity assessment modules and annexes of directives. There is no mention in those documents about prior accreditation but it implies "de-facto". Decision 93/465/EEC clearly denotes that member states which authorize bodies that were not prior with accreditation must maintain an objective proof about their ability of competence.

The second answer placed to the producers is about the product that pertains not to technical legislation of New Approach: is the verification of the product necessary or not depending on market or from some other reasons.

The ISO book concerning “Certification and related Activities” (ISO 1992) gives eight systems for *third-party* certification systems for products (Figure 3.3).

Principally product certification systems should contain at least two activities:

- the acceptance of the product based on testing of the (design of the) product and or the production process,
- the surveillance of the continuing ability of the manufacturer to produce a conforming product.

[4] 93/465/EEC: Council Decision of 22 July 1993.

Certification system 1, type testing only, is not seen as a "mature" certification system, because it provides no form of surveillance by which continuing assurance of conformity is usually assessed. The same is valid for system 7, whereas for system 8, surveillance is not relevant because 100% testing is a system which each and every item "marked" is tested to the applicable requirements.

Certification system 6 relates to the determination of compliance of the supplier's quality management system (ISO 9000) for designated products. No mark on a product is allowed for this system.

Comprehensive system of certification is number 5. It frames type testing in the development phase and QMS supervision in the production phase as well as sample testing where the samples are taken from market and production line.

System component		System certification							
		1	2	3	4	5	6	7	8
Testing	• Type	X	X	X	X	X			
	• Batch						X	X	
	• 100%								X
Surviellance	• Withouth surviellance	X							X
	• By QMS-a					X			
	• By comparsion with oruginally accepted designs			X					
	• By testing sample – open market		X		X	X			
	• By testing sample – factory			X	X	X	X		

Figure 3.3 Voluntary product certification systems

4. CONCLUSION

Today European Union market make 25 states with the common market and population of 450 millions. In the aim of creation of common market it is designed a New and Global Approach about conformity assessment of products, technical harmonization and standardization. Essential requirements for safety product are defined in New Approach directives 23 of them.

The products framed with technical legislation must pass conformity assessment procedure prior to market of European Union, with essential requirements of appropriate directives, defined in Council Decision about introduction of modules for Conformity Assessment number 465/93/EEC. All of these products pertain to the so called «mandatory" certification of product. Producers are in obligation, for products that passed the conformity assessment procedure, to mark with CE sign.

The rest of products are free to emerge on the market. The producers, in the aim of marketing position promotion or from various reasons could perform a "voluntary" certification of product. The most usual it is according to the certification system defined by ISO (ISO 1992).

In all of this cases the manufacturer issue a declaration of conformity of his product with essential requirements of directives and harmonized standards respectively.

LITERATURE

1. Đapić, M., Zeljković, Accreditation Role in the Conformity Assessment Body Notification, Festival kvaliteta, 32 Nacionalna konferencija o kvalitetu, 19-21 May, 2005, (pp. G3-G10).
2. Prešern, S. *Obaveze notifikovanih tela*, Projekt SCG-Quality, Kurs CA-1, Beograd 2005.
3. Blue Guide, *Guide to Implementation of Directives Based on the New Approach and the Global Approach*, Luxembourg: Office for Official Publications of the European Communities, 2000.
4. Gundlach, H.C.W., Marks of Conformity for products (discussion paper), EOTC-European Organization for Conformity Assessment, October 1999.
5. ISO, Certification and related Activities, 1992.
6. Hynd, M., *Role of the Accreditation and the EN 45000 Standards*, Workshop: Notified Bodies, A Key Element in Establishing the Single Market, Brussels, 2001.
7. Becker, U., National Experience - Germany, Workshop: Notified Bodies, A Key Element in Establishing the Single Market, Brussels, 2001.

TOOL WEAR STATUS AND WAVELETS SUCCESSFUL TECHNIQUES IN AN OLD PROBLEM

Ilija Latinovic, Predrag Kezele, Volodja Pezo[1]

Abstract:

Unpredictable tool life and premature tool failure are one of major problems in machining. This paper indicate some modern approaches to identify tool wear status. It is an entry to neural networks and related techniques. The emphasis is on diagnostics though the prognosis and maintenance are accesible with the same means. The methods pertain to advanced manufacturing technology and can not be neglected in future projects and education. Nevertheless these results contribute to concept of complex links between machining and computing.

***Key words**: tool wear, wavelet transform, neural networks*

INTRODUCTION

It is well known that the tool condition monitoring is of great importance in modern manufacturing processes. A tool condition monitoring system is basically an information flow and processing system in which the information source selection and acquisition, information processing and refinement are fully integrated. To achieve greater reliability and robustness in tool condition monitoring, both single and multiple sensing have been investigated for single or multiple tool conditions identification. From the viewpoint of information utilization, the most economical scheme for tool condition monitoring is to employ a single sensor approach. In recent years the acoustic emission (AE) sensing technique has been considered to be one of the most effective methodology for various tool condition monitoring tasks (flank wear, fracture, chiping, chip breakage).

In previous methods the power spectral density of AE signals is computed from Fourier transform based techniques. To overcome some of the limitations associated with the Fourier representation of AE signals, wavelet representation of AE signals is investigated.

The feasibility of combining two very promising techniques [Wavelet Tranformations and Neural Networks (WT-NN)] is investigated.

A family of functions derived from one single function can be expressed by the following equqtion:

$$h^{(a,b)}(x) = |a|^{-1/2} h\left(\frac{xib}{a}\right) \quad (1)$$

where a and b are the dilation and translation parameters, respectively. In the above equation $h(a,b)$ represents the family of wavelets obtained from the single h function by dilations and translations. The given data consists of the f function in the given x coordinate.

The original signal can be reconstructed by using the following expression:

$$f = C\int \frac{da}{a^2}\int db\langle h^{(a,b)}, f\rangle h^{(a,b)} \quad (2)$$

where f is original function. $\langle h^{(a,b)}, f\rangle$ are the inner product of wavelet.

A discrete wavelet transform is used to work with discrete signals.

The original signal can be reconstructed by using the following expression:

$$f = \frac{2}{a+b}\sum_{m,n}\langle h_{m,n}, f\rangle + R \quad (3)$$

Daubechies [1] proposed a wavelet system based on an orthonormal base.

The adaptive resonance theory type neural networks were developed by Carpenter and Grossberg to achieve a self-organized stable pattern recognition capability in real time.

If the input is similar to any of the patterns, it will be placed in the same category with similar paterns. On the other hand, if the input is not similar to any of the previously presented patterns, a new category will be assigned to given input. [2]-[28]

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The system of wavelet networks was introduced by Zhang and Benveniste (1992) as a computational scheme that combines the mathematical rigor of wavelet theory with the adaptive learning properties of conventional neural networks into a single unit

TOOL CONDITION MONITORING SYSTEM

A tool condition monitoring system is shown in figure 1.

Machining

Machining processes involve a number of parameters. Tools with its diameter or geometry, material etc. Cutting conditions like feed rate, depth of cutting, coolant. Working piece, material, initial and a shape at the end of machining. The crucial classification : initial , normal, acceptable and severe tool wear state.

Sensors

The motor current measurement system (Hall current sensor) is relatively simple and its mounting will not affect the machining operations but it is less sensitive than force sensing and AE sensing.

Among indirect methods, AE is the most effective mean of sensing tool wear. The major advantage of using AE to monitor tool condition is that frequency range of AE signal is much higher than of the machine vibrations and environmental noises and not interfere with cutting/drilling/milling operation. [B]

Dornfeld pointed out the possible sources of the AE in metal cutting : plastic deformation during the cutting process in the workpiece; plastic deformation in the chip; friction contact between tool flank face and the workpiece resulting in flank wear; friction contact between tool rank face and the chip resulting in crater wear; colisions between chip and tool; chip breakage; tool edge chipping.

Problems of the technique are how to detect AE signals from rotating tools such as in machine centre (MC) for boring and milling, and how and where to install the AE sensor.

Data collection

The AE signal is ussualy detected by transducers, then amplified and transmited to counter, RMS voltmeter, spectrum analysis, etc.

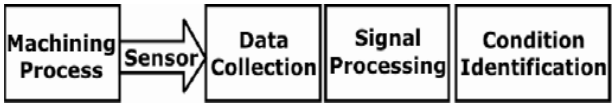

Figure 1.

Signal processing

The analog signals from the AE sensor are digitized and preprocessed in this case. The continous AE signal is stationary in the sense that its mean and autocorelation function are essentially time-independent. The transsient AE signal is non-stationary because its short impulse burst is both frequency and magnitude modulated.

Condition identification

Tool wear state could be clasified into four classifications including: initial wear, normal wear, acceptable wear, severe wear etc.

SET-UP

A successful tool wear detecting method must be sensitive to tool wear change and insensitive to the variation of cutting conditions (cutting speed, feed rate, with or without coolant etc. Transmiting AE signals of rotating tool to AE sensor by liquid medium is one of the most effective method which do not affect the machining process.

The schematic diagram of the experimental set-up is shown in Fig. 2. From a mathematical point of view, the features extraction can be considered as signal compression. Wavelet packet transform is represented as a commpresed signals methods.

At the beginning of the cutting process the AE signal in time domain affected by tool wear is smaller because the tool is fresh. It can be seen that the magnitude of AE in frequency domain are sensitive to the change of tool states.

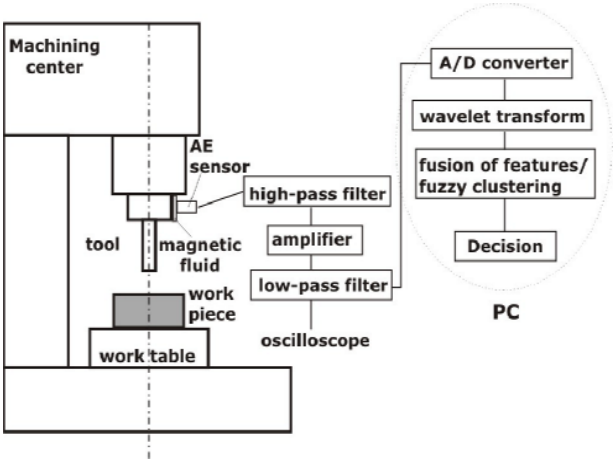

Figure 2.

Wavelet Packet Decomposition (WPD)

Wavelet packets are particular linear combinations of wavelets. They form bases which retain many of the orthogonality, smoothness and location properties of their parent wavelets. The coefficients in the linear

combinations are computed by factored or recursive algotithm, with the result that expansions in wavelet packet bases have low computational complexity

Given an AE signal x(n)(n=1,2,...,N, N=2048), its WPD can be calculated using a recursion of filters h(n) and g(n), which represent the finite impulse response low pass and high pass filters.

$$x_s(n) = F_0(x(k)) = \sum_k x(k)h(2n-k)$$

$$x_d(n) = F_1(x(k)) = \sum_k x(k)g(2n-k)$$

where xs(n) and xd(n) denote sequences resulting from low pass and high pass filter decimation; F0 and F1 denote the operators which perform the convolution of x(n) with h(n) and g(n) respctively, followed by decimation of two. The full WPD is displayed as a tree with discrete sequence at every branch. Each branch sequence is named as a basis vector b. The decomposition may be continued down to the final level where there is only one element in each basis vector.

Any basis sets from the orthonormal bases can be used to represent the analyzed signal. There must be a best basis among them which can represent the signal in the most comact way. Coifman and Wickerhauser introduce a best-basis search algotithm to tackle this problem.
-calculate the information cost of each basis vector $h(\mathbf{b}) = \sum_j p_j \log p_j$, where $p_j = |\mathbf{b}|^2 / \|\mathbf{b}\|$
- starting from the information cost at the bottom level of the WPD tree, whenever a parent node is lower information cost than the total of children, that parent node is marked; otherwise, assign the lower total information cost of the children nodes to the parent node. Repeat this above inductive steps untill all the nodes are eximined. Then the top-most marked nodes from the best basis set.

The best basis wavelet packet consists of N number of coefficients (also termed time-frequency atoms) which contains time (t), frequency (f) and scale (s) information of the analyzed signal. To explicity represent these information, a phase plane representation is employed. A phase plane is a two-dimensional time frequency plane in which each time-frquency atom indexed by (t,f,s) is represented by a rectangular box. The scale (s) is represented by assigned gray scale proportional to the value of s.

The wavelet packet transform decomposes AE signal into components in different time windows and frequency bands. The components which contain the principle components of the original signal are defined as objection of feature selected.

The RMS of of wavelet coefficient of the components selected can be considered as the monitoring features. The feature extracted with wavelet packet transform can be implemented real time since wavelet packet transform requires only a small amount of computation.

Essentially, this approach employs:
• Single AE sensing for multiple tool condition identification.
• Wavelet packet transform (WPT) as the transient AE signal separator and its feature extractor.

Dominant techniques are :
1. unsupervised ART (Adaptive Resonance Theory) neural networks. The individually trained ART2 networks are used for automatic classification of transient tool condition.
2. Fuzzy clustering method (FCM). In general, there are two FCMs used in tool wear monitoring. One is technique based on the fuzzy relationship between patterns and the other is the fuzzy C-means (ISODATA) algorithm.

add1. ART2 clustering possesses several exelent features
o fast incremental learning ability without large samples
o ability to adapt to changing environment
o self-stability
o self-organizing ability in response to arbitrary input sequences

add2. Fuzzy c-means clustering algorithm called ' fuzzy ISODATA' which is one of the unsupervised classification methods. The aim in clustering is to determine the cluster centers, which are representative values of features corresponding to the classified categories. Once clustering centers are determined at the learning stage, the classification is made by comparison of the incoming pattern and each clustering center.

CONCLUSION

This paper has discused the approach of multi-category classification of of tool condition by using single AE information.
1. One of the main obstacles in AE application is how to detect the AE signals from rotating tool. Transmiting AE signals of rotating tool to the AE sensor by liquid medium is one if the most effective methods.
2. The wavelet packet transform is a powerful tool for on-line mionitoring of tool wear. It can captureimprovement features of the sensor signal, namely, features are sensitive to change of tool wear condition, but are insensitive to the variation of process working conditions and various noises. The feature extracted with wavelet packet transform can be implemented real time since WPT requires only a small amount of computation.
3. Pattern recognition using the fuzzy ISODATA algorithm has been succesfuly incorporated into monitoring of the wear states. [1]
4. An ART2 neural network is used to distingush tool fracture, chipping and chip breakage. [rad2]
5. The present technique can be extended to many other AE sensor based monitoring applications such as

breakdown prediction of mechanical components (e.g. bearing and gears) and nondestructive inspection.

REFERENCES

1. Li Xiaoli, Yuan Zhejun Tool wear monitoring with wavelet packet transform-fuzzy clustering method/Wear 219(1998) 145-154
2. Y.M.Niu, Y.S.Wong,G.S.Hong, T.I.Liu, Multi-Category Classification of Tool Conditions Using Wavelet Packets and ART2 Network / Journal of Manufacturing Science and Engineering, November 1988, Vol 120 807-816
3. S.V. Kamarthi, S.R.T. Kumara, P.H.Cohen , Flank Wear Estimation in Turning Through Wavelet Representation of Acoustic Emission Signals / Journal of Manufacturing Science and Engineering, Febryary 2000, Vol 122 12-19
4. Xiao Li, Real-time Detection of the Breakage of Small Diameter Drills with Wavelet transform / The Int. J. of Advanced Manufacturing Technology (1998) 14:539-543
5. S.V. Kamarthi and S. Pittner, Fourier and Wavelet transform for Flank Wear Estimation - a Comparison / Mechanical System and Signal Processing (1997) 11(6), 791-809
6. Ibrahim Nur Tansel, Christine Mekdeci, Charles McLaughlin, Detection of Tool Failure in End Milling with Wavelet Transformations and Neural Networks, Int..J.Mach.Tools Manufact. Vol.356.No8 pp1137-1147,1995

BUSINESS PLAN FOR WORKSHOP FOUNDING

Z. Radojević[1], D. Stojanović[2], J. Avakumović[3]

Abstract:

This study describes founding of a workshop. Such workshop would produce structural steel lattices and booths. This study has all important factors of the business plan.

***Key words**:: business plan, steel workshop, steeel building construction.*

1. INTRODUCTION

Social needs nowadays require forming of small workshops in which products of steel combined with other metals would be produced (steel sheets, steel profiles, aluminum sheets etc.). In other countries in the world such workshops are used for performing service activities. Beside mentioned hereinabove, nowadays, small stores, workshops, exchange offices, dairy stores etc. are mostly being founded since they require a small sum of money. Further in this study is described a whole business plan for founding of a workshop for production of steel lattices and offering of related services.

2. BUSINESS PLAN

Business plan is a document that has all important information of technical and economic character required for opening of a construction project with particular demand and dimension.

2.1. Business plan summary

This business plan has all important information required for founding of a workshop steel in Mirijevo. By market analyzing, it is concluded that such workshop will produce steel lattice booths and perform services in their production. Employees will work 265 working days in one working shift, per year, and produce 60 booths. This means that 24 tones of steel, 132 tones of steel lattices, and total 156 tones of structure will be produced. Production will be performed on site of 250 m2, rented on a period of 10 years. Reproduction material expenses will total 78,000.00 EUR, plus electric current expenses 13,200.00 EUR that amounts 91,200.00 EUR per year. These funds will be provided out of private resources.

2.2. State of the company

By the developed business plan a new workshop will be found. Its owner should have experience in steel lattice and booths sale and in offering related services according to his and existing technical documentation.

2.3. Marketing plan

For workshop founding, the chosen location will be Mirijevo (outskirts of town), municipality Zvezdara. This location is chosen due to cheap renting space and specific type of production, since the production involves hard steel profiles and requires a lot of space for material manipulation. Also, this location must have large stocking area for reproduction material storing.
Workshop working hour will be from 9 AM to 5 PM every day except on Sundays.

2.4. Organization and human resources

Planned scope of production requires 8 employees. The owner will act as main chief and an engineer, who will be in charge of production and assembling. In order to realize production process, it will be necessary to employ 6 sheet metal workers who had already performed work such as making and assembling of steel lattices.

2.5. Workshop legalization

If all assumptions of business plan are accomplished, required space, equipment and financial assets, workshop “Celik” – Mirijevo will be registered.

a) Assets required for investing in equipment
(in EUR)

Loan-making for small and middle enterprises on market, with 7% of interest rate on 5 and 10 years is approved.

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No.	Equipment and types of investment	Quantity	Value	Types of financing
1.	Gas-cutting equipment	2	1200x2=2.400	Credit on 5 years
2.	Welding CO2 equipment	2	2400x2=4.800	Credit on 5 years
3.	10 mm scissors	1	7.000	Credit on 5 years
4.	10 mm press	1	8.600	Credit on 5 years
5.	Measuring scale	1	1.600	Credit on 5 years
6.	Lathe	11	10.200	Credit on 10 years
7.	Drilling machine	1	6.900	Credit on 10 years
8.	Milling machine	1	12.600	Credit on 10 years
9.	Sand blaster	1	8.000	Credit on 5 years
10	Painter	1	4.100	Credit on 5 years
11.	Machine tools and other tools	1	10.200	Credit on 5 years

Table 1. Preliminary estimate of an investment

b) Collective credits
In table 1. we have the following credits on 5 years:

No.	Value in EUR	No.	Value in EUR
1.	2.400	9.	8.000
2.	4.800	10.	4.100
3.	7.000	11.	10.200
4.	8.600	**Σ**	**46.700**
5.	1.600		

Table 2. Credits on 5 years

No.	Value in EUR
6.	10.200
7.	6.900
8.	12.600
Σ	**29.700**

Table 3. Credits on 10 years

According to credit amount and discount factor we will get annuity value per year and month, and the interest rate. When we multiply annuity per year with the number of years for credit repayment (5 years) we will get total amount of credit repayment. When we reduce the total amount of credit repayment for the credit amount, we will get interest rate.
For credit on 5 years: EUR
Annuity per year amounts 11.389,66 EUR.
EUR
Annuity per month amounts 949,14 EUR.
EUR EUR
Interest rate for credit on 5 years amounts 10.248,30 EUR.
Calculation is the same for the credit on 10 years:
Interest rate for credit on 10 years amounts 12.586,1 EUR.
Total monthly credit on 5 and 10 years amounts. : 949,14 EUR + 352,38 = 1301,56 [din per month]

2.6. Total expenses per month and year (u EUR)

Type of expenses	Amount per month	Amount per year
Material expenses	7.600,00	91.200,00
Amortization (15%)	910,00	10.920,00
Gross earnings (8 workers)	3.600,00	43.200,00
Leasehold	500,00	6.000,00
Credit annuity	1.301,56	15.618,72
Other expenses	500,00	6.000,00
Σ	**14.411,56**	**172.938,72**

Table 4. Planning expenses per month and year

2.7. Valuation of total monthly and yearlyincomes (in EUR)

Production and service nomenclature	Measure unit	Quantity		Unit price [EUR]	Income	
		Monthly	Yearly		Monthly	Yearly
Production and instaling of booths	[kom/kg]	2.000	24.000	2,5	5.000,00	60.000,00
Production construction service	[kg]	11.000	132.000	1	11.000,00	132.000,00
				Σ	**16.000,00**	**192.000,00**

Table 5. Planning monthly and yearly incomes

2.8. Available financial assets

Types of assets	Amount [Evra]
1. Private assets of the owner	10.000,00
2. Long-term loans on 5 year:	46.700,00
on 10 year:	29.700,00
Σ	**86.400,00**

Table 6. Available financial assets

2.9. Required financial assets

Types of assets	Amount [Evra]
1. Investment	76.400,00
2. working kapital	9.500,00
3. Gyro account assets	500,00
Σ	**86.400,00**

Table 7. Required financial assets

Assets are provided by self financing of 10,000.00 EUR and by extension of long-term loans of 46,700.00 EUR on 5 years for buying a part of the equipment and of 29,700.00 EUR on 10 years for buying rest of the equipment. Interest rate per year is 7% total. Working capital and gyro account assets are provided by the owner of the workshop.

2.10. Income statement for the first five years of investing and next five year after (u EUR)

Since the profit for the first five years is positive and for the next five years as the table 8 and 9 shows, the conclusion is that the business project should be successful and economically approved.

	2006.	2007.	2008.	2009.	2010.	Amount
INCOME	**192.000**	**192.000**	**192.000**	**192.000**	**192.000**	**960.000**
- Booths	60.000	60.000	60.000	60.000	60.000	300.000
production	**132.000**	**132.000**	**132.000**	**132.000**	**132.000**	660.000
-Services						
OUTCOME	**166.939**	**166.939**	**166.939**	**166.939**	**166.939**	**834.695**
- Purchases	91.200	91.200	91.200	91.200	91.200	456.000
- leasehold	6.000	6.000	6.000	6.000	6.000	30.000
-	10.920	10.920	10.920	10.920	10.920	54.600
amortization	43.200	43.200	43.200	43.200	43.200	216.000
- salaries	**15.619**	**15.619**	**15.619**	**15.619**	**15.619**	**78.095**
- annuity						
GROSS PROFIT	**25.061**	**25.061**	**25.061**	**25.061**	**25.061**	**125.305**
Tax (10 %)	2.506,1	2.506,1	2.506,1	2.506,1	2.506,1	12.530,5
NET PROFIT	**22.554,9**	**22.554,9**	**22.554,9**	**22.554,9**	**22.554,9**	**112.774,5**

Table 8. Income statement for the period from 2006 to2010 years

	2011.	2012.	2013.	2014.	2015.	Amount
INCOME	**192.000**	**192.000**	**192.000**	**192.000**	**192.000**	**960.000**
- Booths	60.000	60.000	60.000	60.000	60.000	300.000
production	**132.000**	**132.000**	**132.000**	**132.000**	**132.000**	660.000
-Services						
OUTCOME	**155.549**	**155.549**	**155.549**	**155.549**	**155.549**	**777.745**
- Purchases	91.200	91.200	91.200	91.200	91.200	456.000
- leasehold	6.000	6.000	6.000	6.000	6.000	30.000
-	10.920	10.920	10.920	10.920	10.920	54.600
amortization	43.200	43.200	43.200	43.200	43.200	216.000
- salaries	**4.229**	**4.229**	**4.229**	**4.229**	**4.229**	**21.145**
- annuity						
GROSS PROFIT	**36.451**	**36.451**	**36.451**	**36.451**	**36.451**	**182.255**
Tax (10 %)	3.645,1	3,645,1	3.645,1	3.645,1	3.645,1	18.225,5
NET PROFIT	**32.805,9**	**32.805,9**	**32.805,9**	**32.805,9**	**32.805,9**	**164.029,5**

Table 9. Income statement for the period from 2011. to2015. years

2.11. Project valuation

a) Terms of funds return

Terms of funds returns amount:

$$RV = \frac{10.000}{22.554,9} = 0,44$$

b) Critical point of profitability

$$\text{Critical point (threshold) of profitability} =$$

$$= \frac{\text{Fixed expences}}{1 - \frac{\text{Variable expenses}}{\text{Realization income}}} = \frac{10.920}{1 - \frac{156.019}{192.000}} =$$

$$= \frac{10.920}{1 - 0.81} = \frac{10.920}{0,187} = 58.395,72\,[\text{din per year}]$$

c) Margin of certainty

$$\text{Margin of certainty} = \left(1 - \frac{\text{Scope at the turning point of profitability}}{\text{Existing scope of sale}}\right)$$

$$\text{Margin of certainty} = \left(1 - \frac{58.395,72}{192.000}\right) \times 100 =$$

$$= 0,695 \times 100 = 69,5\ \%$$

According to high marginal certainty, one may see that the workshop is stable compared to market oscillation and regarding this type of service.

2.12. Conclusion

According to mentioned hereinabove, we think that the business project shall be successful and economically approved for the realization. We could've seen that the creator of idea invested 10,000.00 EUR and lent a long-term loan from financial institution with 7% of interest rate on 5-years period, 46,700.00 EUR total, and on 10-years period, 29,700.00 EUR total. This loan should be returned on credit repayment date and so should be stated in the income statement for the mentioned period.

3. REFERENCES

1. Bangs D: *The Business Planning Guide*, Dearborn Financial Publishing, Inc., 1998.
2. Jovanović P.: Project management, FON, Belgrade, 2004.
3. Jovanović P., Radojević Z., Savanović G., Ćebić D.: Business Founding and Management, VTTS, Beograd, 2005.
4. Rieva L: *Start Your Own Business*, Entrepreneur Media Inc. 2001.
5. Strauss S.: *The Business Startup Kit*, Dearborn Trade Publishing, 2003.

DEVELOPMENT OF BUSINES POSSIBILITIES IN FORMATION AND RE-FORMATION OF ORGANIZATION

Cedomir Avakumovic[1], Julija Avakumovic[2]

Abstract:

In this research, authors have discussed questions of importance small enterprises, terms of engineering and entrepreneurship. Accent is on importance of re-formation enterprises from the aspect of analyzing adequacy, idea, managing and supposition for realization that business attempt.

***Key words**: small business, entrepreneur, engineering, idea*

1. INTRODUCTION

In observing period of time, many organizations originate and disappear. More of them pass through changes which are designed and re-designed by them managers. We can meet with more definitions of small business, and we always can be sure that small business has got important role in our life. Many activities – economics activity, in our life we have done with managers of small business.

Small business is "place where everything has begun". Phrase "engineering" mean programming, building and operation. In practice engineering is including more information content. It is cumulative term for more successive actions – important for implementation production and services, from the decision of choice technology, action, way of action and identification the most rational work process, analyze of adequacy, ideas, managers part across constitutive premise for realization business possibilities, planning of projects and realization of projects.

Special function of entrepreneur is ability to take all facts to production – land, work and capital, and take it's to make new goods or services.

Entrepreneur has to identify possibilities which the other business people could not able to identify or are not interested in.

2. DEVELOPMENT PURPOSES OF THE BUSINESS POSIBILITIES

Entrepreneurship is different term than management. Paul H.Wilkin has got opinion that entrepreneurship contains initialization changing in production, on the other side management including permanent coordination of production process. He says: "entrepreneurship incoherent phenomenon, which appear to introduce changes in production…and after that evanescent, buy only till appear again to start with new changes".[1]

Entrepreneurship is primarily something in conjunction with incoherent process in which are combination substance to product new goods and services.

In our earlier passed, importance was to big enterprises - system. After its "smash", men were not being able, and in present time man hard accept paradigm of new age of production development that the most of new employment places are in opening and helping small business.

It is necessary to help development of small business, shops, and agencies and to changing ambience of industrial development introduction new way of production and new kind of services.
Entrepreneurship could make four priorities for some society. Its incentive economic growth; incentive production; incentive new technology, production and services; changing and rejuvenate concurrency on the market.[2]

To make more successfully development of business possibilities of entrepreneurship engineering, we have to make thinks on the next way:

- Dedicate enough care on potential entrepreneur which have more idea to make better development of society,
- Analyzing their personality, skills and manners, like as condition for their development,
- Find facility to help entrepreneur with which they could continue with help the others and explain

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reasons for which they could start action of new business action and make new organization for that action,
- Advert entrepreneur attention on intensive need and right analyze of business comparison offer with financial and the other risks with which business enterprise included,
- Make analytical process of facts which could make risk of business in future,
- Make to entrepreneur possibilities to develop plan with which could prevent fact of risks and fortify emergency.

3. DEVELOPMENT OF BUSSINES POSIBILITIES OF ENTREPRENEURSHIP

Through opinion of business possibilities of entrepreneurship is necessary to make clear situation and give answers on next questions and do critical analyze:

- Analyze of adequacy,
- Ideas,
- Managerial parts,
- Substantial suppositions for realization defense – suggested business capability, and
- Rational make decisions.

3.1 Analyzing of adequacy or payable

Adequacy and payable are possible to understand like "capacity to use something or to make trading with something". Success we can define like criterion for profit or growth interest. Analyze of payable or validity is kit for evaluation fluctuation with which owners of business could realize in business. This "changing" could be on: development of new product or services, promotion existent goods or services, change marketing strategy or complement of strategy, expansion or reduction new business and make new organization.

In frame of analyzing of adequacy and process of payable are necessary to include and to view: timetable, goals which are rational (specifically, measurable, attainable, real and confident), criteria and make minimum which have to be filled to continue project, fortify goals of study of adequacy, phase of development business chance and possibilities like as phase of analyze validity and process of making analyze of validity.

3.2 Ideas

In view of any idea, it is important to envisage facts and critically analyzing some of the next questions:

- Whether idea should to fill up our goals?
- Which facts or terms could prevent bad way of idea?
- Are there some point, obstacles or surprises on the way which could prevent making idea?
- Is some usage of any idea could be enough to vindicate price through cost, personal sacrifice and engage family?
- Are we ready or not to adapt process of internal entrepreneurship, rather to attend beginning of usage and development of new business in frame of structure existent organization,
- How much we are ready to except idea about our organization like "flexible" and members of that organization like "independent" to make new ideas, goods and relationship, and how to
- Make daily care about re-design of ours organization.

3.3 Managerial part

Within of this research of managerial part, possible are to give answers on next questions:

- Which kind of managerial part are missing to establish for efficiency control in our organization?
- Whether are we able to control that skills, or if we are not – have we got power to make arrangement with somebody who know that?
- In which phase of development our organization, could manifest deficiency of skills and become restrictive factor in development of organization?
- Whether we obtain understanding of our family to give support to our idea and accept risk – failure of our business?

3.4 Suppositions for realization of business possibilities

Hypotheses which we have for realization of our business possibilities are: technical and market aspects, criteria for counter value, prices and financial questions.

While we monitoring technical question, we have to answer on next questions:

- Have we access to row materials, auxiliary goods and intermediate goods?
- Have we enough knowledge about technology, equipment and process of production?
- How much is system for production adequate for arrangement and usage of our product organization?

In approach of market situation, we have to give answer on next questions:

- With which base we need to meet our product or services?
- About description of goods or services which we have to place on the market,
- Analyze of the market – current setting,
- Analyze of market partition,
- Target market,
- Analyzing of concurrency,

- Which concurrency product, goods or services are strong or weak, and which characteristics of them are strong or weak?
- Could we make situation on our side and take some priority in quality and quantity?

We have to monitoring some criteria of counter value and give some answers on next questions, there are:

- What are minimum of value of prices necessary for maintain alive of project?
- Whether potential of grow adequate and are they suitable?
- Whether our product the best option and is that option available for us?

While we approach prices and finance like important question, we have to analyze some of the next questions:

- Have we got ready money for start new business?
- How long times we have to spend for attain money flow?
- How much are cost in the first business year?
- When we can expect return of invested funds?

3.5 Rationally in decisions making

To make rational decision, first of all we have model of rational making decision. In authors opinion the best solution is to have on as like Model from book "Management", published by James A. F. Stoner, R.E. Freemont and D. R. Tolbert Junior. That Model has to include next four phases:

1. Test situation,
2. Find alternative,
3. Evaluation of alternative, and
4. Make the best choice and implementation in monitoring of decision.

4. CONCLUSION

The most important task of modern business activity is to give answer on the key question of the modern business activity and to give answer on entrepreneur and managerial activity in technology and innovation branch.
Organizations are forming, passed, changing, and again change influence in entrepreneurship which could make again forming existent organization.
It is important to make clear next questions and make analyze of adequacy, idea, managerial skills and substantial supposition for realization business possibilities – technical, market, financial and risks which could control to minimize influence of negatively coincidence.

LITERATURE

1. Paul H. Wilken, Entrepreneurship: A Comparative and Historical Study (Herwood, N.Y., Ablec Publishing, 1979) page 60
2. James A.F. Stoner: Management (Zelnid, Belgrade, 2000)

BUSINESS ETHICS AND FREE ENTERPRISING SYSTEM

Dr Savo Trifunović[1]

Abstract:

For the reason that free enterprising system in our country is still at the first stage of development (in the phase of open market), the business ethic following such economy is elementary as well. Especially after nineties, due to expanding application of automation and robotics in the business, human work is increasingly depersonalised. Economic recession "generates" growing economical and social insecurity – till the turbulences. The influence of the competition is more expressed and of international global characteristic. Fluctuation of more fluid available manpower is more explicit, more international and "sufficient". Lifelong employment illusion disappears while the existing one becomes uncertain. System of educational institution provides mostly decreasing education and moral values. Social and payment differences become grater in amount. Permanent renew of education of the managers, enterprisers, workers appears as first-class urge It seems that the reality is full of immorality – from the point of social ethics and social orders given to the business. It also seems that the business is full of moral behaviour, from the point of business orders that are given by the business itself. However, dissents to the orders of the social responsibility, intention to relieve from general moral, are increasingly present. Business features justify these dissents, behaviour,, which is actually halted by many of standards of general social morality, preventing it to be «successful machine for products, money and profit making». It is not expected business ethics will have greater influence on business if there is no increasing ethical activities for instance, political, public institutions which (in)directly have an affect upon business and ethic behaviour of the companies and employees.

***Key words** : business ethics , free enterprising system, doubts , moral , business , perspectives , development*

1. SOME BUSINESS ETHICAL DOUBTS

For the reason that free enterprising system in our country is still at the first stage of development (in the phase of open market), the business ethic following such economy is elementary as well. On account of that, we are expected to look at some of the problems, doubts, requests that are immanent to the business and business ethic in the countries which already have that kind of system and which haven't experienced socialism. Some of the intentions are already present in our country

Teamwork, productiveness, working groups homogeneity, individual moral qualities could be expressed in the period of relatively stabilized economic growth, lifelong employment in one company (permanent employment), with the same people, at the same working position, with the regular payment and possibility of becoming perfect and making improvement. Self-giving, conscientious work, satisfying payment, solving of house providing problems, expert special training paid by the company, different awards, «relatively beneficent» legislation, have been sufficient motivations for business ethical behaviour.

The workers could identify themselves with the company and its values. (1)

They could be involved in problems solving in active manner because it was of their concern (till the workers identification with the company – « my company»). Especially after nineties, due to expanding application of automation and robotics in the business, human work is increasingly depersonalised. Economic recession "generates" growing economical and social insecurity – till the turbulences. The influence of the competition is more expressed and of international global characteristic. Fluctuation of more fluid available manpower is more explicit, more international and "sufficient". Lifelong employment illusion disappears while the existing one becomes uncertain. System of educational institution provides mostly decreasing education and moral values. Social and payment differences become grater in amount. Permanent renew of education of the managers, enterprisers, workers appears as first-class urge. In that context, nowadays, subjective (thematic) focus of business ethic is displaced from institutional responsibility to the moral capability of the individual. Laura L. Nash gives indicative list of ethical uncertainties, doubts that managers take into account nowadays. Those moral doubts are:

- Greed
- Hiding and incorrect evidence in reports and during examining procedures
- Statements causing wrong conclusions regarding quality of the products and services

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- Avoiding of keeping ward or deceiving regarding agreed conditions and terms
- Accepting business politics which will probably make other people telling untruth with the intention to complete the business
- Exaggerated certainty of self-made estimate regarding corporation's entity risk
- Insufficient loyalty to the company in a time of difficulty
- Bad quality
- Humiliating people in their working places or by commercial stereotypes
- Obeying authorities without objections in spite of their unethically and dishonourable behaviour
- Self-raising above corporation's responsibilities (conflict of interests)
- Favouritism
- Price arrangement
- Sacrifice of powerless and innocent people with the intention to obtain certain goals
- Repelling of basic rights: freedom of speech, elections and personal relationship
- Neglect to mention unethical activities
- Family and personal needs carelessness
- Making decisions on products which application can endanger the public security
- Failing to return expropriated, from the funds of employees or corporation
- Conscious overstatement of some plan advantages purposing to obtain necessary support
- Neglect to solve problems of possible intolerance, male-female relations or racialism
- Flattering to the people on the higher positions instead of conscientious duties performing
- Improving position on the corporation's scale without regard to other people
- Improving position of destructive intrusive person making excuses for his errors before their arising
- Fail to cooperate with the other parts of the company-hostile attitude.
- Lying employees by giving incomplete information, allegedly for the business, making association with suspected partners evening the case of the good reason
- Refuse to accept the responsibility for harmful practice – intended or unintended
- Insulting corporation's blowhards that are wasting both time and the money or accepting their actions
- Corrupting of public political process by means of legal system

Length of the list is the most interesting. Those are not rare problems occurring once in the career –those are well known doubts. (2)

Business is one of the social activities. It is product ional and serviceable activity, which satisfies many social needs, as integral part of the society, business is «applying» to the rules of the social, ethical behaviour. Nevertheless, the business is specified by the necessary features of business activities and which, due to their specificity, «generate» characteristic reasons of the moral evaluation, conclusions, behaviour. Is it possible and should the business possess «its» own moral? If yes, may it differs and in what degree, from the generally accepted social moral values? Is the myth of unmoral business just the story, or it is a reality even nowadays? The answers are too complicated and demand accurate elaboration without intentions to be entire.

It seems that the reality is full of immorality – from the point of social ethics and social orders given to the business. It also seems that the business is full of moral behaviour, from the point of business orders that are given by the business itself. And there is a question of range and aims of the business ethics as a part of general ethics, that is to say its intention to be ethics on it's own disregarding general ethics.

There are eight elements (orders) of business social responsibility presented by Milton Freedman (in New York Times):

- Business should be honour
- With no deception in interpersonal relationship
- Showing respect towards conventions on honour competition
- Showing respect towards lows
- Showing respect towards contracts
- Showing respect towards the rights of the employees and investors
- Aiming towards the most possible satisfaction of the clients
- Acting in the way that allows free choice of individuals taking part in business process

However, dissents to the orders of the social responsibility, intention to relieve from general moral, are increasingly present. Business features justify these dissents, behaviour,, which is actually halted by many of standards of general social morality, preventing it to be «successful machine for products, money and profit making».

Business characteristics in business moral mirror could be described by mentioning the following distinctive attitudes:

- Our ethical or unethical behaviour is not a question for businessmen. We are just dealing with business. And we obey rules and «rules» of the business. Ethical principles and ethical ideals of the society are one thing, but business principles are completely different thing. «We are acting in extremely competitive enviroment.If we want to continue our activities we have to keep searching the profit wherever it is legally allowed. We don't make laws.. We respect them. Why should we tolerate these conversations about ethics in style « better catholic than Pope»! It is explicit hypocrisy. We are not dealing with the business to promote ethics. For God's sake, look at the companies producing cigarettes! If the lawmakers haven't built in the ethics, the businessmen are not expected to fulfil the emptiness. Sudden turning businessmen to the Christian ethics would produce the greatest economical disturbances in the history.» (3)

«Never tell untruth using words», but think and conduct the strategy of illusion and cheating; verbally always stay moral. Be moral as much as you like, but only when you are not in business. That's your individual

«afternoon» problem.

- Telling truth but never «the whole truth»
- Business doesn't make laws.
- Intelligence operation is allowed. Using intelligence operation in business is not more disgracing then using it by the state... Intelligence in business is not ethical question, it's conventional technique used by competition in business». (4)

Hide facts purposely, overreact if necessary, introduce yourself wrongly – if it is on behalf of yourself.

« Untruth stops from being untruth when all parties understand that the truth is not expected to be told»

« Business is the game. Act like a player. Bluff, if necessary –to survive in business.

Play to win.

Commonsensical ethical values (nobility, honesty,. Faithfulness, sincerity, serviceability, respectfulness, keeping promises) that are available on the market are good «for myself» but not «from myself»

Business is making money and the profit on free market, which is ruled by eternal uncontrolled greed, and ravening moral, which is hard to defeat by "lamb's arguments"

Unscrupulousness, tendency to deception, hypocrisy are some of elements of Machiavellianism in market game .All means are ethical if lead to my goal.

Bribe, corruption conducted by the others, why wouldn't I do it? It's hard to be under pear tree and don't eat pears .Do not discuss and speak of unethical actions, cheatings, manipulations. Silence is better and do not endanger flexibility of management and business.

Such, shortly mentioned «business moral ideology» causes decreasing of moral standards authority, produces some specific behaviour including all negative consequences regarding social values and business ethics. Erosion of confidence, decreasing loyalty of the companies, scandals, moral silence (i.e. growing caricature presentation of the management), are some of fundamental features of organizational behaviour and business life. Expanding of embitterment, distrust, dissatisfaction, struggle for survival, short term payment emphasizing, indifference towards other people, ethics» me and only me at the first place».

2. PERSPECTIVES OF BUSINESS ETHICS DEVELOPMENT

Business ethics is ethical process. It is altering, but it is not passing. The same is with the man and its work. It is also ethical consciousness and ethical rules as well. Business is in its centre, and man should know that.

The urge for the business ethics is greater than ever. The ethics of the free market as " controlled greed" appeared especially after historical decline of socialism. Globally, socialism came down from the historical scene together with its positive values. The world of nowadays is more and more world of capitalism – in different phases of its development- from transitional to informational phase. New capitalism, world capitalism ought to become good society. It's not just theoretical order of the actions. It should be a reality. Called for new (and the only) order to be good and effective, it should be humanised. It ought to integrate all positive values of socialism - which were its advantages, aiming to maximize huge working, willing and moral energies. Today it is the only strategic direction of further development and further changes which should mean material, spiritual and moral progress as comparable process. And that is not easy. It seems that the greatest problem is altering of the conscience and understanding of the changes essence. Business and business ethics are especially important in that process. They also have particular responsibility.

Due to committed global changes, achieved civilization degree of evolution, strong development of material production power (till automatically , robotically and cybernetic integrated production systems), today it is necessary to treat the business ethic, ethos of the company, ethics of the managers more wise and sophisticated. Naturally, it is also for each person composition allowing to act wrong (intentionally or unintentionally) due to insufficient readiness and deciding to abstain from the challenges of the money and the power. (5)

The personal interest of the companies, which was up to now a priori in advantage, should be directed towards business ethical values of each employee and towards general ethical values of the society. According to Laura L .Nash, they will have to introduce "agreeably business ethics".

Business will have to be more directed towards essential meanings as business values, rather than towards business goals that could be quantified in quarter, annual reports. Of course, ethic could not be quantified. We think that the further intention to do the business, disregarding ethical essence of the business, really could be the same as trying to change the tyre on the vehicle without using bumper jack. " There is no guarantee the ethics is worthy. But there is no guarantee the ethics is not worthy." (6)

«Moral atmosphere « of the work, moral speech (not moral silence) have to get complete «civil rights» in annual reports of companies business. Just enlarged conception of business morality could clearly explicate disturbing of psychological and moral integrity of employees and contribute to advancing of business morality, that is to say business activity as well.

We see further perspectives of business ethics development in achieving higher degree of moral culture of the company (moral corporation culture) and in maintaining of the moral autonomy and identity of each employee in extend context of moral culture of the company (corporation culture). «Hewlett – Packard, which owns one of the most powerful culture, which is called « the way HP does it», is proud of its human oriented philosophy... or ....Companies of high morality in all ways are trying to avoid problem of NTMN (Nobody Tells Me Nothing) ..or It seems that they all (

companies of the high morality) follow the ninth command of Fletcher Birom from 3M company:» You have to make a reasonable number of mistakes». Some ones even celebrate them.» (7)

It is not expected business ethics will have greater influence on business if there is no increasing ethical activities for instance, political, public institutions which (in)directly have an affect upon business and ethic behaviour of the companies and employees.

More stabile conditions of producing will also have the positive influence on extending implementation of the morality in business. Since business ethics could not be imposed to the companies that means they are the most responsible for ethic behaviour. (8)

It is acknowledged: ethical behaviour of the managers, from the point of individual factors of personality and working socialisation, is modelled and of the greatest affect upon employees. If the behaviour of the managers is unethical, "epidemic" is ready to break. Therefore, business ethic have to start from the top management. Ethical codes, ethical professional training certainly will be very useful.

It is acknowledged: it's easy to be moral and respect business-ethical standards while you are strong enough. We also know : primary property of the company will appear as high ethical standards of employees behaviour, and iron cage between manager's personality and his morality will have to be removed. In that respect, Laura L. Nash, emphasizes with arguments and not without reason, that " good business and destiny of the capitalism depend on intended maintaining of complex net of ethical values." (9)

LITERATURE

1. To see , Trifunović, Savo (1986): " O radnom moralu danas ", Revija rada , br. 177., str. 23-30.
2. Laura L. Nash Whence now business ethics?, anthology Business ethics (2001), edited by John Drummond and Bill Bain, Clio, Belgrade, page 27-28.
3. Albert Z .Kar: Is bluffing in the business ethical?», anthology Business ethics,(2001), Clio, Belgrade. Page50.
4. (Albert Z. Kar, op. cit. p. 48)
5. To see , Trifunović, Savo (2003): « Poslovni moral i menadžment », Zbornik naučno – stručnog skupa «Menadžment u industriji», Kruševac, jun 2003.,str. 163 – 168.
6. Mark Pastin: Ethics as integrating e power in management" anthology Business ethics op. cit., p. 109.
7. Michel V. Hoffman: What is necessary to achieve high morality of the corporation?, anthology Business ethics, , op. cit., p. 70 – 71.
8. To see, Trifunović, Savo (1996): Radni moral, MFK, Kraljevo, pp. 7 – 10.
9. Laura L. Nash, op. cit. p. 30.

ABOUT ETHICAL CODEX OF MANAGERS

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Abstract:

Organizations and associations nowadays are expected to determine, introduce and actualize ethical codices. Professionalism, connectedness, civilization development, general urge for business ethics improvement and introducing of superior standards, position of managerial profession are only some of reasons for increasing interest of ethical codices implementation. Ethical codices should not be regarded as identical to business bon ton. Ethical codex is written document representing basic group of professional standards. It is one of the evidences of professional status. It explicite regulates: Basic values of profession, Professional ethical principles, Professional standards, Regulating and disciplinal mechanisms, but and roles of the etical board, ethical court, business ethics officer, ethical ombudsman.Determination and acquiring of professional ethical codex doesn't mean that all members of the profession will follow ethical behaviour and ethical standards, or that they haven't followed them up to present time. The idea is to act with good intentions, from the ethical pint of view, to improve professional practice and to define general ethical business criteria. Codex of managerial ethics acts and is verified only and always by concrete business (work) of concrete people (managers) as the most superior parameter of codex ethic, ethic of profession, ethic of managers Increasing number of managerial ethical codices in our society will be good indicator of extending acceptance and accomplishment of collective and social responsibility of managers. We are still at the beginning phase.

Key words *: ethics , business , business bon ton , ethical codex , ethical board , ethical court , business ethics officer , ethical ombudsman , codex of managerial ethics*

1. BUSINESS ETHICS AND BUSINESS MORAL ACT

Business ethics is one of the essential features (from the point of human anthropological view) of human being in the process of its work and one of the greatest capabilities regarding possibilities of modern man, modern society and expanding scientific and technical-technological power of the world of work. Recognizing yourself as individual, working and social being; searching for the personal essence of the existence in business world; conducting ethical-business- working recognizing and self-recognizing through practical working activities producing good and enabling good life among concrete people- act reasonable and in the manner of the human being-are just some of the eternal aims and crucial reasons for modern men's necessity of (business) ethics.

Totality of working, moral and ethical is not always expressed in certain functionally –practical moral aim. From the extended point of view, indicating single superior aim of morality and ethics is actually expression of eternal tendency for searching, acknowledging of complexness and totality of moral and ethics integrity.

Sometimes it is en expression of historical limits of certain period of time, certain social relations and permanent man's imperfection. Sometimes, however, it is en expression of apology of certain social (mainly owning) relations and authorities structure.

Every economical, production, serviceable, operational-business activity, every concrete business action is not necessary concurrently moral activity, concrete moral action as well.

All incompletenesses are not in the function of the integrity. The integrity is an aspiration, but incompleteness could be separated from the integrity, estranged and even become destroying against the business integrity. However, each incompleteness of business action, if it is incorporated into wholeness, has potential of moral act – with the condition that the incomplete subject becomes subject, creating wholeness in a way that other people, subjects in business process are represented as human, moral aim. For that, there is no more superior social or economical action above moral action. Though possible moral action, business action is specific activity for the reason that moral action is the most human action.

Business ethics is not just a work, just a business. It is also a life value, sensibleness, thinking,

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willing, hope, usefulness, language, intuition, intimate belief, salvation, purpose.

We cannot make the whole business ethics and its aims using one business-ethical act. They are always single aims; from the point of integrity of the business ethics – they are always partial. But, even such partial, business ethical acts, from the point of view of possible realization of human wholeness in specific social circumstances, are in special way integral for being en expression of creatively practical and human power.

Differently from other human activities business moral act has essentially expressed unity: a) human personality, b) work-business, c) society, d) humanization, axiology. And other human activities have similar content, but it is especially indicated (and characteristic) in business moral act. It is, however, predominated by components of the personality and components of man's valuable direction. (1)

Organizations and associations nowadays are expected to determine, introduce and actualize ethical codices. Professionalism, connectedness, civilization development, general urge for business ethics improvement and introducing of superior standards, position of managerial profession are only some of reasons for increasing interest of ethical codices implementation.

Ethical codices should not be regarded as identical to business bon ton.

Business bon ton in organization is generally understood and related to all employees. It is a measure of taste, work pleasance, help to business success and excellence, outstanding element of work culture, measure of ethic in communications and behavior between employees and outside the company.

Despite the fact that the business bon ton is actually understood, organizations often decade to express it in written form to uniform in ethical manner behavior, appearance, behaving rules with respect to the individual personality and position in organizational structure and similar.

Business bon ton often regulates rules of behavior at meetings (formal and informal), at business gathering, dates, in social life related to work. (2) Business bon ton suggests kinds and manners of contacts face to face (e.g. the first business meeting, manner and style of conversation during applying to the position, contacts between superiors and their subordinates, colleagues, buyers and suppliers, arguing conversation, respect of discretion, informing of colleagues, establishing of business relations).

Business bon ton also advices the best way of business correspondence performing, phone contacts, treating businessmen from the same country and from other countries (respecting cultural, habitual, linguistic, ethnical, religious differences), manner of mutual acting between companies (avoiding "land mines") e.g. respect hierarchy, be loyal to your company, praise your company, be honest, learn to loose, respect common interest, etc.)

General target of business bin ton are good business manners contributing to successful business, long term solid business relationships, personal development, increasing work satisfaction.

2. ETHICAL CODEX

Ethical codex is written document representing basic group of professional standards. It is one of the evidences of professional status. It explicite regulates:

- Basic values of profession
- Professional ethical principles
- Professional standards
- Regulating and disciplinal mechanisms

Ethical codex is fundament of professional behaviour direction. It defines essential areas of ethical actions and ethical responsibility. Ethical codex regulates solving ethical professional problems. Ethical codex is compelled for all members of certain association, group.

Ethical codex should:

1. Regulates rules of managerial professional behaviour and real intention – up to ethical ideals within profession:
2. To be explicit and well-defined and to regulate specifically professional questions representing temptation of the managers, «ethical traps» of mangers profession and « land mines» which are unethical, but not always illegal behaviours;
3. To protect common and public interest and not only interest of managerial profession;
4. To define rules, procedures and mechanisms of practicing of ethical codex standards;
5. Members of managerial profession for their awareness of correct and incorrect behaviour should create this ethical codex. They are aware of «the traps» of profession. (Therefore, they should have certain degree of autonomy regarding non-professional social control).

Meaning of ethical codex is professional promotion from the ethical aspect as well. It directs ethical behaviour and responsibility of members of (profession) association, individual and related to group behaviour as well, preserving ethical features of the profession.

At the first place, certain professions within professional associations introduced ethical codices. Today, according to increasing business ethical requests, there are more companies implementing ethical codices often expressing fundamental ethical values and models of behaviour in relation to all segments of the business.

Ethical codex of managerial profession insists on professional work and professional loyalty honour and integrity, responsibility, accuracy, love of truth, individual professional and ethical improving, progressing of managerial knowledge and skills, permanent education and self- education, accepting general standards of good taste in behaviour.

Managers are expected to accomplish professional ethical standards such as to carry out obligations conscientiously and in accordance with the best personal knowledge in relation to the colleagues within the same profession and in relation to the ones

cooperating in professional work (apart from the hierarchical position). He should act according to personal example. He ought to comply professional acting with general interest of society (public interest), with professional interest, with interest of organization. Manager should respect human rights and freedom, all standards of cicilization achievements; especially he should respect the ideal of individual free opinion and free opinion of others. Therefore, he should respect fundamental principles of personal dignity developing cooperation, understanding among individuals, groups, and institutions.

Manger must not destroy his own reputation and the reputation of his profession and practice behaving in a bad manner. Forbidden practice is the one involving bribe, corruption, conflict between individual, organizational interests and state processes; representing interests of the competition; possessing of the secret accounts and accepting illegal payments up to impelled gifts; intentionally, consciously destroying of professional reputation and practice of managers colleagues.

Ethical codex define the composition and the role of ethical board as special organ composed from few often the most respectable managers, which control ethical codex implementation and general ethical behaviour in organization. Ethical board is responsible for the most compound question of ethical codex and their practical application (with the consequences). The Most frequently, ethical board is conducting the function of ethical court which is responsible for decisions making and pronouncing judgments on ethical codex standards violation and immoral, i.e. amoral behaviour. State courts are not disciplinal organs promoted by ethical codex and they are not expected to be that. The most frequently, to prevent ethical codex rules violation, they use critique, public announce, elimination from the professional organization.

Ethical codex (but it's not the only one) defines business ethics officer, business solicitor, «specialist for business ethics is a full right member of managers board or other bodies making crucial decisions, acting as social conscious and critically inquire decisions morality, that is he illuminates dimension of their ethical implications. This prevents negative influence of collective opinion or conformation, and ignores ethical principles and dimensions of business decisions.» (3)

Ethical codex usually defines ethical ombudsman, ethical commissioner. He is a » member of organization with duty and responsibility to follow and investigate of complaints and problems considering ethical aspects of business and management decisions and behaviour. He investigates complaints regarding those problems and informs top management of ethical omissions. Basically, he has a role of organizational ethical conscious. « (4)

- It is not good for managerial ethic codex to:
- Be list of wishes and big ethical ideals which are aimed to in professional managers practice;
- Emphasize only general moral values at the first place (honesty, love of truth...), that is to say, forbid telling untruth, stealing, because these are general ethical values. They are understood. They are valid for all, and for the managerial profession as well. Such «structure» in managerial ethical codex is sufficient;
- Be list of rules regulating professional behaviour;
- Express dominating order of disciplinal rules
- Require lower ethical request from managers than the ones required by the society (state)

It is also not good that the agencies of professional managerial associations announce post festum, e.g. after pronouncing a verdict of crime committed by members of association.

Determination and acquiring of professional ethical codex doesn't mean that all members of the profession will follow ethical behaviour and ethical standards, or that they haven't followed them up to present time. The idea is to act with good intentions, from the ethical pint of view, to improve professional practice and to define general ethical business criteria. Will ethical codex survive, it first of all depends on managers behaviour in business situation and generally in managerial practice.

They make decisions- they ought to respect codices. " Managers are " members of leading group" This group, however, has outstanding, easily obvious position, and authorisations. Therefore, it also has a responsibility. But what are the responsibilities, what are moral principles of single managers, members of elite group? In essence, being a member of leading group means being what is traditionally described by phrase " professional". Being a member of such group denotes status, remarkable position, authorisations, but obligations as well. It is uselessly to expect each manager to become a leader. In highly developed society there are thousands, even millions managers, but leadership is always rare exception involving only uncommon individuals. But being member of leading group, manager is always under pressure of professional ethics requests and demands of ethics of responsibility «. (5)

The complexity of human personality and situation is present in managerial practice with all challenges of personality and the situation (practice). The ethical codex would be unneeded if all managers were moral in their business behaviour. Since this is not the reality, ethical codex as intention to better and superior levels of business ethics practice, is strong motive and expression of the sense. Insufficient presence of morality in managerial profession practise causes ethical codex – though result of immorality, which is increasingly present in professional practice, needn't result in ethical codex. These are some of discussion questions of (un) need of ethical codices in managerial profession. The question of relation between normative and real, range and final reaches of ethical behaviour norming is still open. Manager, as expert is not expected to be ethics expert. What ethical codex wants is that the managers' expertness is practised simultaneously with high ethical principles and professional standards. That means good management is at the same time good ethical deduction and behaviour

(practise), acting good, not causing damage.

Codex of managerial ethics acts and is verified only and always by concrete business (work) of concrete people (managers) as the most superior parameter of codex ethic, ethic of profession, ethic of managers. Absence of ethical codices regulation stands for complete social (state) control of professions. Each profession has its social importance and justification and it means social (not strictly professional) responsibilities. Like other professions, managerial profession has a specific social value; it includes specialised knowledge and competence; supposes prolonged education aiming achieving specialised knowledge and skills (it couldn't be replaced by some other profession); calls for higher own requests than the society (state) is asking for

Increasing number of managerial ethical codices in our society will be good indicator of extending acceptance and accomplishment of collective and social responsibility of managers. We are still at the beginning phase.

LITERATURE

1. To see, Trifunović, Savo (1996): Radni moral, MFK, Kraljevo, str. 13 – 39.
2. For more details see: David Robinson (1998): Business bon ton, guide on business and etiquette, PS «Grmeč», Belgrade. Some «golden rules»of good business manners are mentioned.
3. Lexicon of management, (2001), editors: Fikret Bahtijarević – Šiber and Pero Sikavica, Masmedia, Zagreb, p. 107.
4. Lexicon of management, op. cit. p. 107.
5. Peter Ducker (2003), My Viewpoint of Management. Ideas that improved management, Adizes, Novi Sad, p. 53.)

DEFINITIVE SUM OF SOME SERIES

Smiljković S.[1]

SUMMARY

This work does with setting up and proving a new relation between the numbers. These are the numbers that must be written by the certain rule, but like that they have one specific reciprocal relation. It consider the posibility of widening this rule to all series which can be present like these numbers.
Setting up these relations between the numbers can lead out directly consequences which are valid for them. And you can combine reciprocal, giving new complex numbers which fit this rule.
Key words: *number, serie, interval, sum.*

1. INTRODUCTION

This rule (theorem) is something that we are coming upon for the first time in the mathematics. Till now it is still in development, and it is yet up to be completely researched and defined. Also, and its significance. For the beginning, I placed it in the sphere of number theory, although it might not belongs to this sphere of mathematics. It should be possible after defining of this theorem.
The basic theorem and some of its direct consequences are placed and argumented in this paper, and could be a good base for its own further exploration and development. For easier understanding, there is a characteristic example for each rule or underule. Also, it should be mentioned that this theorem will be valid even if all terms are placed all at once, that is if all of these numbers consist of all possible additions that are included and argumented in this paper, what could be of importance for writing very complex number systems.

2. THEOREM

If the first number (A) is a decreasing series of digits, second number (B) increasing series of the same digits, third number (C) decreasing series of the same digits (with casting out the largest digit and leading in the next smaller digit of the already existing smallest digit), and the fourth number (D) is increasing series of digits of the third number, it follows:

$$\mathbf{J = A - B - C + D = 0}$$

$$A = \sum_{i=0}^{m-1} (n - i) \cdot 10^{(m-1-i)\cdot x}$$

$$B = \sum_{i=0}^{m-1} (n - m + 1 + i) \cdot 10^{(m-1-i)\cdot x}$$

$$C = \sum_{i=0}^{m-1} (n - 1 - i) \cdot 10^{(m-1-i)\cdot x}$$

$$D = \sum_{i=0}^{m-1} (n - m + i) \cdot 10^{(m-1-i)\cdot x}$$

n - the first number in number $(A, B, C \text{ or } D)$, $n > 1$;
m - the number of numbers that are series $m \le n$;
x - number of numbers (digits) in n;

Proof:

$$J = A - B - C + D =$$

$$\sum_{i=0}^{m-1} (n - i) \cdot 10^{(m-1-i)\cdot x} - \sum_{i=0}^{m-1} (n - m + 1 + i) \cdot 10^{(m-1-i)\cdot x} -$$

$$\sum_{i=0}^{m-1} (n - 1 - i) \cdot 10^{(m-1-i)\cdot x} + \sum_{i=0}^{m-1} (n - m + i) \cdot 10^{(m-1-i)\cdot x} =$$

$$\sum_{i=0}^{m-1} (n - i - n + m - 1 - i - n + 1 + i + n - m + i) \cdot 10^{(m-1-i)\cdot x} =$$

$$\sum_{i=0}^{m-1} 0 \cdot 10^{(m-1-i)\cdot x} = 0$$

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Example:

$n = 99 \qquad m = 3 \qquad x = 2$

$$A = \sum_{i=0}^{m-1} (n-i)\cdot 10^{(m-1-i)\cdot x} = \sum_{i=0}^{2} (99-i)\cdot 10^{(2-i)\cdot 2} =$$
$$= 99\cdot 10^{2\cdot 2} + 98\cdot 10^{1\cdot 2} + 97\cdot 10^{0\cdot 2} = 999897$$
$$B = \sum_{i=0}^{m-1} (n-m+1+i)\cdot 10^{(m-1-i)\cdot x} = \sum_{i=0}^{2} (97+i)\cdot 10^{(2-i)\cdot 2} =$$
$$= 97\cdot 10^{2\cdot 2} + 98\cdot 10^{1\cdot 2} + 99\cdot 10^{0\cdot 2} = 979899$$
$$C = \sum_{i=0}^{m-1} (n-1-i)\cdot 10^{(m-1-i)\cdot x} = \sum_{i=0}^{2} (98-i)\cdot 10^{(2-i)\cdot 2} =$$
$$= 98\cdot 10^{2\cdot 2} + 97\cdot 10^{1\cdot 2} + 96\cdot 10^{0\cdot 2} = 989796$$
$$D = \sum_{i=0}^{m-1} (n-m+i)\cdot 10^{(m-1-i)\cdot x} = \sum_{i=0}^{2} (96+i)\cdot 10^{(2-i)\cdot 2} =$$
$$= 96\cdot 10^{2\cdot 2} + 97\cdot 10^{1\cdot 2} + 98\cdot 10^{0\cdot 2} = 969798$$

$$J = A - B - C + D = 999897 - 979899 - 989796 + 969798 = 0$$

3. DIRECT AFTERMATH

3.1 There is a possible existence of digits, anywhere in the numbers, which are not in relation with interval / intervals, but they must be repeated on the same place, in every number and solution is undependable. And then we can difference three states:

1. If the digits are after the interval, the following formulas are used:

$$A = \sum_{i=0}^{m-1} (n-i)\cdot 10^{(m-1-i)\cdot x+p} + E$$
$$B = \sum_{i=0}^{m-1} (n-m+1+i)\cdot 10^{(m-1-i)\cdot x+p} + E$$
$$C = \sum_{i=0}^{m-1} (n-1-i)\cdot 10^{(m-1-i)\cdot x+p} + E$$
$$D = \sum_{i=0}^{m-1} (n-m+i)\cdot 10^{(m-1-i)\cdot x+p} + E$$

p - number of digits in E

E - digits that are added (presented as a number)

1) Proved as same as the theorem.

2) Example:

98765432333 – 23456789333 – 87654321333 + 12345678333 = 0

2. If the digits are before the interval, the following formulas are used:

$$A = \sum_{i=0}^{m-1} (n-i)\cdot 10^{(m-1-i)\cdot x} + E\cdot 10^{m}$$
$$B = \sum_{i=0}^{m-1} (n-m+1+i)\cdot 10^{(m-1-i)\cdot x} + E\cdot 10^{m}$$
$$C = \sum_{i=0}^{m-1} (n-1-i)\cdot 10^{(m-1-i)\cdot x} + E\cdot 10^{m}$$
$$D = \sum_{i=0}^{m-1} (n-m+i)\cdot 10^{(m-1-i)\cdot x} + E\cdot 10^{m}$$

p - number of digits in E

E - digits that are added (presented as a number)

1) Proved as same as the theorem.

2) Example:

33398765432 – 33323456789 – 33387654321 + 33312345678 = 0

3. If the digits are in the middle of the interval, the following formulas are used:

1) Proof:

If $A = N_1N_2EEN_3N_4$, $B = N_4N_3EEN_2N_1$, $C = N_2N_3EEN_4N_5$ and $D = N_5N_4EEN_3N_2$, then:

$J = A - B - C + D =$

$N_1N_2EEN_3N_4 - N_4N_3EEN_2N_1 -$

$N_2N_3EEN_4N_5 + N_5N_4EEN_3N_2 =$

$N_1 10^5 + N_2 10^4 + E10^3 + E10^2 + N_3 10^1 + N_4 10^0 -$

$N_4 10^5 - N_3 10^4 - E10^3 - E10^2 - N_2 10^1 - N_1 10^0 -$

$N_2 10^5 - N_3 10^4 - E10^3 - E10^2 - N_4 10^1 - N_5 10^0 +$

$N_5 10^5 + N_4 10^4 + E10^3 + E10^2 + N_3 10^1 + N_2 10^0 = 0$;

therefore we can see that EE does not effect the solution.

2) Example:

98763335432 – 23453336789 – 87653334321 + 12343335678 = 0

3.2 There could be an infinitively many different intervals that are inferior to the rule.

1) Proof:

This rule can be considered as an underule of the previous rule. The main interval becomes any of the already given ones, while the others are considered as digits that are not in relation with the (chosen) interval[2]. According to that, the argument of the previous consequence also stands and for this one. This method

[2] These digits are analog to those of the first consequence.

could be, afterwards, applied to all others intervals in the number.

3.3 Decimals does not effect the solution, that is, the comma could be anywhere in the number, but it must be on the same position in every number.

1) Proof:

$$\frac{A}{q}-\frac{B}{q}-\frac{C}{q}+\frac{D}{q}=\frac{(A-B-C+D)}{q}=\frac{0}{q}=0$$
$$q\in\{10,100,1000,...\}$$

2) Example:

$$98765,432-23456,789-87654,321+12345,678=0$$

3.4 If every number is decreased or increased for the same value, solution stays unchanged.

1) Proof:

$$(A+r)-(B+r)-(C+r)+(D+r)=$$
$$=(A-B-C+D)+(r-r-r+r)=0+0=0$$
$$(A-r)-(B-r)-(C-r)+(D-r)=$$
$$=(A-B-C+D)+(-r+r+r-r)=0+0=0$$

2) Example:

$$(98765432+341986)-(23456789+341986)-$$
$$-(87654321+341986)+(12345678+341986)=0$$
$$(98765432-341986)-(23456789-341986)-$$
$$-(87654321-341986)+(12345678-341986)=0$$

3.5 If every number is decreased or increased the same number of times, solution stays unchanged.

1) Proof:

$$A\cdot r-B\cdot r-C\cdot r+D\cdot r=(A-B-C+D)\cdot r=0\cdot r=0$$
$$\frac{A}{r}-\frac{B}{r}-\frac{C}{r}+\frac{D}{r}=\frac{(A-B-C+D)}{r}=\frac{0}{r}=0$$
$$r\neq 0$$

2) Example:

$$(98765432\cdot 18)-(23456789\cdot 18)-$$
$$-(87654321\cdot 18)+(12345678\cdot 18)=0$$
$$(98765432\div 18)-(23456789\div 18)-$$
$$-(87654321\div 18)+(12345678\div 18)=0$$

3.6 The difference of the first and the second number $(A-B)$ is equal to absolute value of the difference of the fourth and the third number $(D-C)$.

1) Proof:

$$A-B=$$
$$\sum_{i=0}^{m-1}(n-i)\cdot 10^{(m-1-i)\cdot x}-\sum_{i=0}^{m-1}(n-m+1+i)\cdot 10^{(m-1-i)\cdot x}=$$
$$\sum_{i=0}^{m-1}(n-i-n+m-1-i)\cdot 10^{(m-1-i)\cdot x}=$$
$$\sum_{i=0}^{m-1}(m-1-2\cdot i)\cdot 10^{(m-1-i)\cdot x}$$

$$D-C=$$
$$\sum_{i=0}^{m-1}(n-m+i)\cdot 10^{(m-1-i)\cdot x}-\sum_{i=0}^{m-1}(n-1-i)\cdot 10^{(m-1-i)\cdot x}=$$
$$\sum_{i=0}^{m-1}(n-m+i-n+1+i)\cdot 10^{(m-1-i)\cdot x}=$$
$$-\sum_{i=0}^{m-1}(m-1-2\cdot i)\cdot 10^{(m-1-i)\cdot x}$$

$$|A-B|=|D-C|$$

2) Example:

$$98765432-23456789=75308643$$
$$12345678-87654321=-75308643$$
$$|75308643|=|-75308643|$$

3.7 The difference of the first and the third number $(A-C)$ is equal to absolute value of the difference of the fourth and the second number $(D-B)$.[3]

1) Proof:

$$A-C=$$
$$\sum_{i=0}^{m-1}(n-i)\cdot 10^{(m-1-i)\cdot x}-\sum_{i=0}^{m-1}(n-1-i)\cdot 10^{(m-1-i)\cdot x}=$$
$$\sum_{i=0}^{m-1}(n-i-n+1+i)\cdot 10^{(m-1-i)\cdot x}=$$
$$\sum_{i=0}^{m-1}1\cdot 10^{(m-1-i)\cdot x}=\sum_{i=0}^{m-1}10^{(m-1-i)\cdot x}$$

[3] These differences are numbers that are consisted only of digits 1.

$D - B =$

$$\sum_{i=0}^{m-1}(n-m+i)\cdot 10^{(m-1-i)\cdot x} - \sum_{i=0}^{m-1}(n-m+1+i)\cdot 10^{(m-1-i)\cdot x} =$$

$$\sum_{i=0}^{m-1}(n-m+i-n+m-1-i)\cdot 10^{(m-1-i)\cdot x} =$$

$$\sum_{i=0}^{m-1}(-1)\cdot 10^{(m-1-i)\cdot x} = -\sum_{i=0}^{m-1}10^{(m-1-i)\cdot x}$$

$$|A - C| = |D - B|$$

2) Example:

98765432 – 87654321 = 11111111
12345678 – 23456789 = –11111111
$|11111111| = |-11111111|$

3.8 The sum of the first and the fourth number $(A+D)$ is equal to sum of the second and third number $(B+C)$.[4]

1) Proof:

$A + D =$

$$\sum_{i=0}^{m-1}(n-i)\cdot 10^{(m-1-i)\cdot x} + \sum_{i=0}^{m-1}(n-m+i)\cdot 10^{(m-1-i)\cdot x} =$$

$$\sum_{i=0}^{m-1}(n-i+n-m+i)\cdot 10^{(m-1-i)\cdot x} =$$

$$\sum_{i=0}^{m-1}(2\cdot n-m)\cdot 10^{(m-1-i)\cdot x}$$

$B + C =$

$$\sum_{i=0}^{m-1}(n-m+1+i)\cdot 10^{(m-1-i)\cdot x} + \sum_{i=0}^{m-1}(n-1-i)\cdot 10^{(m-1-i)\cdot x} =$$

$$\sum_{i=0}^{m-1}(n-m+1+i+n-1-i)\cdot 10^{(m-1-i)\cdot x} =$$

$$\sum_{i=0}^{m-1}(2\cdot n-m)\cdot 10^{(m-1-i)\cdot x}$$

$A + D = B + C$

2) Example:

98765432 + 12345678 = 111111110
–23456789 – 87654321 = –111111110
$|111111110| = |-111111110|$

[4] These differences are numbers that are consisted only of digits 1 & 2.

4. GENERAL OBSERVATION

This rule (theorem) is not valid when the number is consisted of the series of numbers that are on crossing over from tenth to ones, from hundreds to tenths, thousands to hundreds, etc. that is, instead of 0 it gets number divisible with 9.

5. CONCLUSION

Considering that this rule is still insufficiently examined, it is hard and irresponsible to make any conclusion of greater importance; so at this stage we should concentrate more on further exploration. However, I could point out some directions that could make further work easier. There is a certain regularity of the reciprocal multiplication (division) of these numbers. Also, there could be further exploration about the numbers that are on the crossing over, as mentioned before. There are also indications that this rule could be expanded and generalized to all the serieses, etc. that it could be used to all the serieses that are inferior to the starting conditions.
Special use of this theorem is still blurry but with certain modifications and improvements it could have certain significance for coding.

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REGIONAL CITY LOGISTICS AND SUPPLY CHAINS IN MACHINERY

Bukumirović M., Gašić M., Savković M.,G. Marković[1)]

In this paper the scope of goods exchange of Kraljevo region with foreign countries is analyzed. The aim of analysis is estimation of scope of goods flow as one of the starting parameters for introducing the innovations in industrial warehouse and for development of city logistics concept based on concentration of goods and information flows.

***Key words**: industry, development, region, city logistics, supply chain*

1. INTRODUCTION

Rapid development of industry and information technologies have caused introducing the innovations in industrial warehouses and goods transport. These innovations are influenced not only by industry development and product increase but by the level of realized goods flows i.e. by export and import as well.

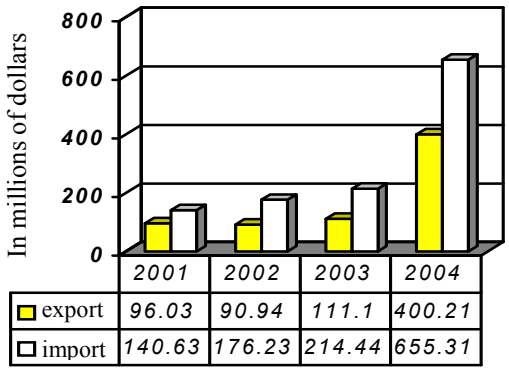
2. PRESENT CONDITION OF PRODUCTION SYSTEMS AND GOODS EXCHANGE IN KRALJEVO REGION

Development of city logistics is the feature of big cities but also of the regions where towns are closely connected in goods transport.

There are three municipalities in Kraljevo region with more than 300.000 inhabitants and distance among them being not longer than 100km. Total goods exchange between this region and foreign countries is more than 300.000 dollars. The exchange scope (as well as exchange in the region that is not included by this estimation) enables the problem of development of new industrial warehouses and city logistics to be taken into consideration.

Data on export and import in Kraljevo region for period from 2001-2004 (fig.1) also prove the abovementioned. The numbers in fig.1 present the millions of dollars.

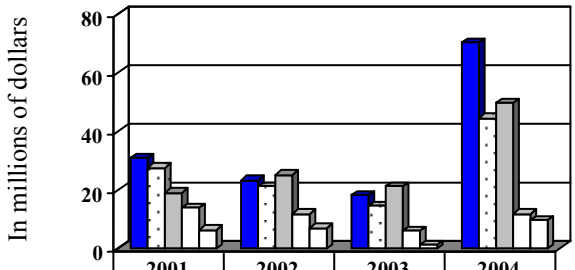
In 2002 35.77% of total goods exchange in Kraljevo region was realized as an import and 64.23% as an export. In 2004 the export was increased on 37.9% but the import increased for 514 million dollars. Data on the region corresponds to the trend of goods exchange of Serbia and they are even a bit favourable.



	2001	2002	2003	2004
export	96.03	90.94	111.1	400.21
import	140.63	176.23	214.44	655.31

Fig.1

Some significant and the most important partners are shown in figures 2 and 3, respectively.



	2001	2002	2003	2004
Germany	30.8	23.4	18.3	70.4
Italy	27.6	21.4	14.6	44.6
BiH	19.1	25.1	21.3	49.5
Macedonia	13.9	11.9	6.1	11.9
G.Britain	6.4	7.1	1.3	9.9

Fig.2

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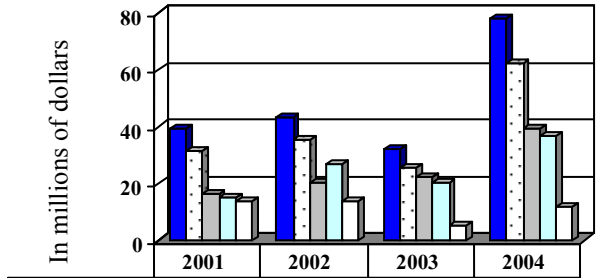
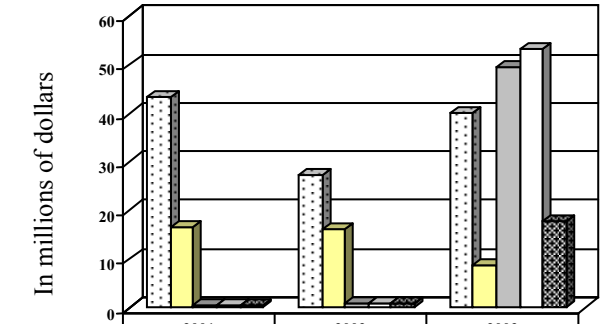


	2001	2002	2003	2004
Germany	39.6	43.2	31.9	78.4
Italy	31.6	35.2	25.7	62.6
Chezh Republic	16.1	20.5	22.1	39.1
Turkey	15.2	26.9	20.5	36.5
Macedonia	13.6	13.7	4.9	11.5

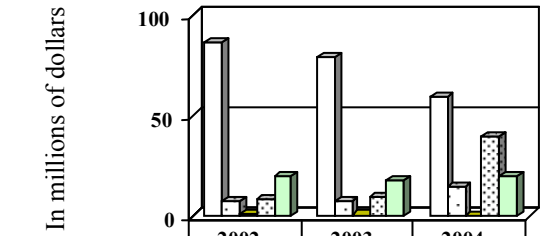
Fig.3

Figures 4 and 5 show the exchange of goods and products in some industry branches. Figures 4 and 5 show the scope of export and import from 2002-2004, respectively.



	2001	2002	2003
Machine ind.	43.6	27.2	40.3
Wood ind.	16.4	16.1	8.6
Copper	0.7	1.1	49.4
Aluminum	0.4	0.9	53.2
Custom ind.	0.4	0.8	17.9

Fig.4



	2002	2003	2004
Machine industry	86.4	79.4	59.8
Wood industry	7.6	7.7	14.9
Copper	0.6	0.5	0.4
Aluminum	8.7	8.9	39.8
Plastic production	19.8	18.1	19.6

Fig.5

3. CENTRAL INDUSTRIAL WAREHOUSE IN REGIONAL LOGISTIC CENTRES AND CITY LOGISTICS

Strategic up-to-date orientation of our economy forecasting development of small and medium enterprises points out the need for a new approach to improvement of regional prosperity. It must be started from basic requirements: decrease of both production and goods price and increase of the service quality level.

Very useful solution for improvement of business management in the regions is forming and development of regional logistic centres with a centralized industrial warehouse. In logistic centres all activities on total flow and retaining of the goods[2)] in the region would be concentrated [1].

The experiences of developed European countries show that basic activities of logistic centres (goods and transport centres, distributive centres) and their supply are:

- Supply, keeping and retaining of goods (especially for the needs of the region),
- Reloading of goods (in these kinds of transport),
- Incoming and outgoing remote, regional and local transport of goods,
- Collective and distributive transport,
- Additional and service activities (informational control systems, load exchange etc.)[1].

The stated activities clearly point out the basic aims and tasks of the logistic centres and supply chains in the sectors of industrial (production) economy, traffic economy, living conditions etc. These aims and tasks are the following:

- Improvement of economy structure,
- Enabling the faster and wider development of small and medium enterprises (production and service ones),
- Making conditions for general improvement of regional development,
- Improvement of service quality,
- Decrease of transport costs and goods stocking,
- Improvement of functioning efficiency of the whole distributive system, especially the town and production enterprises supply,
- Improvement of traffic structure,
- Improvement of space plan,
- Large energy savings,
- Improvement and protection of the environment.

2) Term goods means the most various products: material, half-finished material, finished material,…

Basic manner for decrease of both production and service costs is the adoption of new strategy supplying the consumer with materials/goods "just in time" i.e. when they are needed in production or when the service is being done.

The mentioned requirement implies that small and medium enterprises should have a central warehouse/distribution centre, from which the needed goods, materials, half-finished materials, components, etc. would be supplied just in time for immediate installation/production. It is irrational that the enterprise structure covers those quantities and assortments in the warehouses. So, the solution is forming the collaborative industrial warehouse either as part of the logistic centre or as the beginning of development of the regional logistic centre.

The central regional industrial warehouse can be structured in two ways:

- Centralized for whole region in one location, or
- Decentralized in more sub-regional locations in the city centers which are mutually integrated by information technologies.

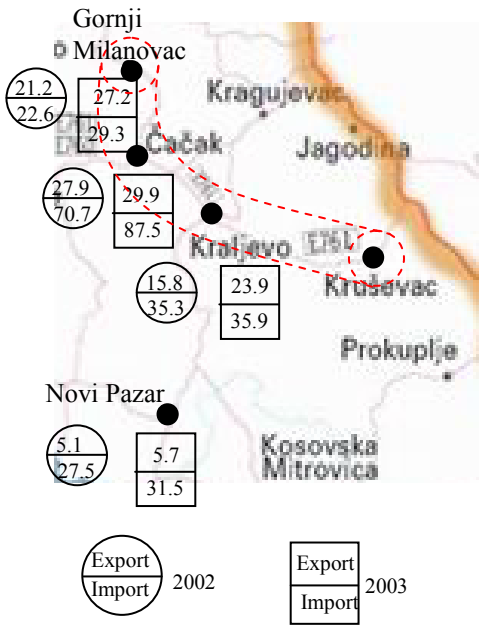
When choosing the warehouse type one should bare in mind that application of information technologies enables the decentralized warehouse to be treated as centralized and both of them as part of the regional logistic centre.

By right choice of location of industrial warehouse and logistic centre the city logistics is basically improved as well as city and regional transport, which influences both the application and maintenance of travelling network.

4. THE NEED FOR CITY LOGISTICS DEVELOPMENT IN KRALJEVO REGION

For most European countries the problem of goods transport in cities is becoming current at the moment when the number of inhabitants exceeds 100.000 and when transport is being done on a distance up to 50km. According to geographic location of the towns in the region (fig.6) Kraljevo region has a line characteristic in the city logistics sense with exception of Gornji Milanovac. The analyses show that about 80% of transport is realized at the distance shorter than 50km. The important thing is that about 50% of road transport costs are realized in city transport and delivery.

Except financial parameters it is also important to mention that lorries make noise which is 10 times louder than the noise made by cars and that more than 50% of exhaust gases are made in traffic. [2].



In millions of dollars
Fig. 6

Having in mind these data as well as the geographic location of this region (Kraljevo is about 50km far from Čačak and Kruševac but in opposite directions) and the increase of total goods exchange of the region, planned industrial development (after privatization, re-engineering of equipment and technologies) it can be stated that the conditions for starting then project of city logistics development in this region as well as new concept of centralized industrial warehouse and supply chains are made.

Each town, in this case the region as a whole, requires its own concept of city logistics which must be constantly followed and developed. In order to realize a project like this one must estimate and analyze a number of parameters related to this problem, firs of all the strategic concept of city logistics and forming the knowledge base [5].

Development of city logistics conception in the region is based on the concentration of goods, transport and information flows. In order to develop this concept adequate logistic centres must be formed and supply chains connecting incoming and outgoing goods flows must be provided (fig.7).

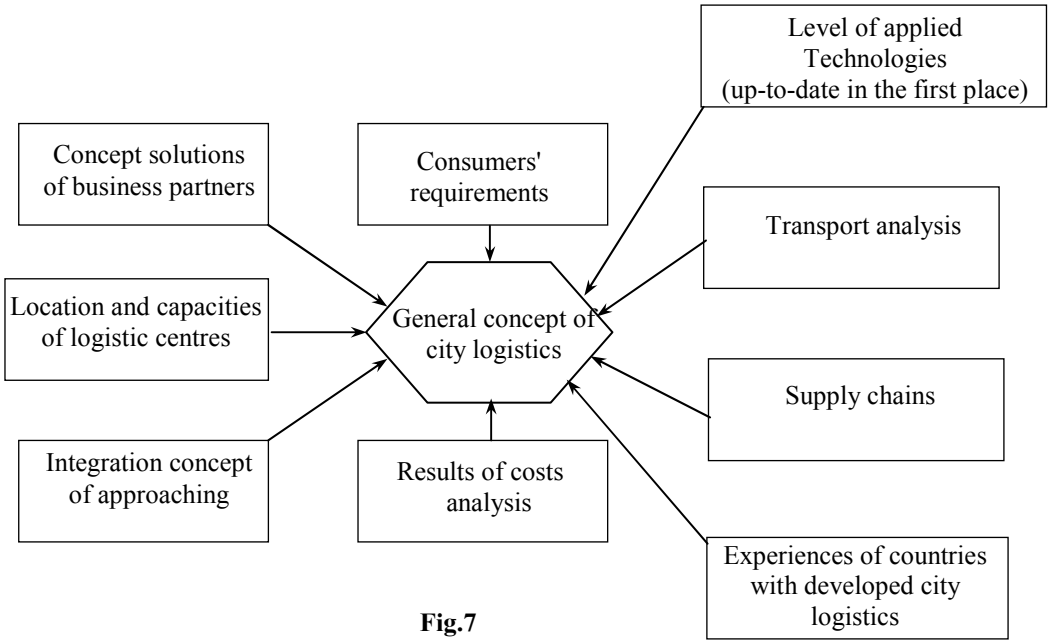


Fig.7

5. SUPPLY CHAINS AND THEIR MANAGEMENT

A supply chain is a network of means and distributive options supplying material, transform it into half-finished material and distribute it to the consumers. There are supply chains both in production and service business organizations.

In a word, the supply chain is a part of the process where the products are made and delivered to the consumers. The supply chain is a complex network of relations and it is managed by companies in order to acquire raw material and half-finished material, to make new products, sell them and finally to deliver them to buyers. The management of the supply chain is coordination of material, information and finance flows among all the companies participating in business transactions:

- Material flows include transfer of physical products from the supplier to the consumers through the chain, as well as reverse material flows such as reclamation of sold and delivered products, maintenance, recycling etc.;
- Information flows include prediction of demand, order transfers and reports on the status of single deliveries;
- Financial flows include information about the credit cards, credit conditions, payment terms etc.

Information and Communication Technologies (ICT) have enabled costs and effective spreading of information among various subjects in the supply chain. New strategies for the supply chain, such as Vendor Managed Inventory (VMI), Collaborative Planning, Forecasting and Replenishment (CPFR) and Efficient Consumer Response (ECR) have started to exploit these new communication channels at the end of retail supply chain. The influence of electronic management on supply chain of producers and on suppliers of material/components is less understood and exploited.

Some of basic strategies for supply chain (fig. 8) are:

- Decreased strategy- with one participant less in a supply chain,
- Electronic shopping-with distributive network being overcome and information and material flow is directly done between the consumer and the producer,
- EPOS- with information beimg transferred from the market to all companies in the supply chain,
- VMI simulated by development of the protocol between two participants in a supply chain giving necessary information about the stock and sale, authority and responsibility toward the supplier so that he could manage the consumers' stock.

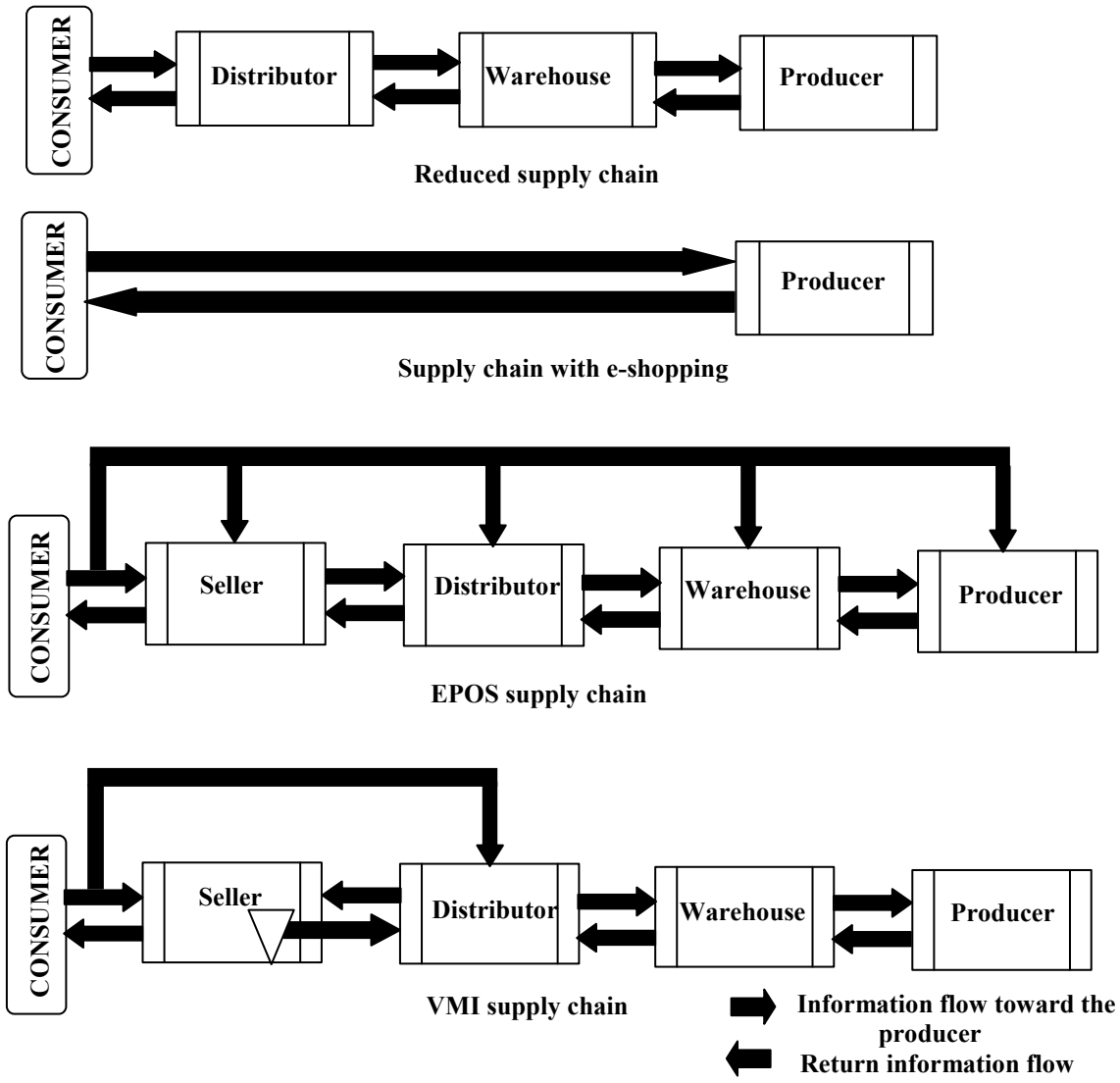


Fig. 8

In the screenplay where EPOS is approved the sale to final consumers is obvious to all members of the supply chain. The situation is the same as in numerous shops supply chains where data are available by the Internet or directly from the retailer or through the third groups and can be used by members of supply chains so that forecasts would be generated. In this strategy data on sale can be used by any participant, but each participant still should deliver the ordered (if it is possible). Particular VMI screenplay that is under consideration is the following: distributor in two member VMI relation manages the retailer's stock. Distributor is given the information on the sales and retailer's stock. The retailer in this screenplay does not place the orders to the distributor but believes he will set appropriate stock quantities in order to have enough (but not too much) stock at the retailer's.

The other participant in this screenplay (warehouse and factory/producer) functions in traditional mode.

Transport is one of the most important element in logistics costs for most of the companies. In practice, each supply chain management begins with transfer of raw materials or half-finished materials, than it includes internal flows and ends up with outgoing flow of finished products. Because of that transport management is of key importance for supply chain improvement.

Transport management includes:

- Transport planning,
- Determination of directions and distribution of vehicles in dynamic schemes,
- Selection of transport type (road, railway, air transport)
- Warehouse management, and
- Providing the functioning of return roads and continual transports.

Along with improvements in transport system product prices at big geographic (national) markets can be quite lower and favorable for most of the consumers.

5. CONCLUSION

The analysis of presented results of goods exchange shows that goods exchange is on the increase and that it might have sudden increase. In the region Kraljevo has the position of a central unit, its number of inhabitants is considered to be current for development of the regional city logistics. Transport requirements in supply chains, ecologic requirement and the need for living quality in stated towns in the regions particularly point out the significance of location selection of logistic centres as well as the manner and time for their supply.

6. REFERENCES

[1] Perišić R.:"Savremene tehnologije transporta II", Saobraćajni fakultet, Beograd 1991.

[2] Zečević S., Radivojević L.:"City logistika- Nova rešenja u robnom transportu u urbanim sredinama", Tehnika 54, Beograd 1999.

[3] Podaci Regionalne privredne komore Kraljevo.

[4] Aden D.:"City logistik und Werenverteilzentren", Logistik Johrbuch, 1998.

[5] Bukumirović M., Savković M.:" Regionalni privredni razvoj i city logistika", Menadžment u industriji, Kruševac 2003.

ТЕРМОСТОЙКИЕ ПОКРЫТИЯ НА ОСНОВЕ СИЛИКАТОВ ЩЕЛОЧНЫХ МЕТАЛЛОВ

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Аннотация

Представлены результаты исследования влияния минеральных наполнителей на свойства силикатного связующего с целью получения термостойких защитных покрытий для металлических конструкций строительных, дорожных и технологических машин.

Термозащита, металл, силикатное связующее, наполнитель, вспучивающиеся покрытия

На безопасность работы строительных, дорожных и технологических машин существенное влияние оказывает наличие термостойких покрытий, которые обеспечивают защиту основных узлов машин от действия высоких температур [1].

По механизму действия при высокотемпературном воздействии защитные покрытия классифицируются на горючие, трудногорючие, негорючие невспучивающиеся и вспучивающиеся. Наиболее эффективными являются вспучивающиеся покрытия т.к. при высокотемпературном воздействии они плавятся и вспучиваются за счет выделения негорючих газов, а образующийся пенококс защищает подложку от внешнего теплового потока. Толщина покрытия увеличиваются в 2-200 раз, а теплопередача в сторону металла уменьшается примерно в 100 раз [2]. Толщина, структура и особенности термического поведения образовавшегося пенококса связаны с составом и с соотношением основных ингредиентов композиции.

Проблема разработки эффективных вспучивающихся термостойких покрытий (ВТП), оказывающих также антикоррозионное действие и экологически безопасных – актуальна. Необходимо отметить, что в настоящее время ассортимент эффективных ВТП представлен дорогостоящими композициями и в большинстве случаев основан на применении синтетических смол в органических растворителях, что небезопасно с экологической и технологической точек зрения. Вспучивающиеся термостойкие покрытия являются уникальными покрытиями, защищающими металл не только от высоких температур но и от воздействия кислорода. [3,4].

Для определения возможности использования горных пород и отходов промышленного производств ЦЧР для создания ВТП в Воронежском государственном архитектурно-строительном университете (ВГАСУ) были проведены теоретические и экспериментальные исследования. Целью данных исследований являлась разработка оптимальных составов, вспучивающихся термостойких покрытий для конкретных материалов и температурных границ с высокими теплоизолирующими свойствами. В задачи

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исследований входило изучение влияние минеральных наполнителей разных генетических классов на свойства силикатов щелочных металлов. В изучаемых композициях исходным связующим явился калиево-натриевый силикат (жидкое стекло), которое при температурном воздействии разлагается с выделением воды и относится к классу экологически безопасных самовспучивающихся связующих.

Минеральные наполнители вводились в состав силикатного связующего, смесь тщательно перетиралась и наносилась на исследуемые металлические пластинки размером 10x10x0,1 см для определения прочности, адгезии.

Коэффициент вспучивания и плотность определялись на образцах, получаемых в специальной форме 2x2x2 см. Исследовалось влияние минеральных наполнителей на свойства силикатного связующего в диапазоне температур от 20 до 1000°С.

Для проведения экспресс-метода оценки термозащитных вспучивающихся свойств композиций была собрана специальная установка, которая состояла из электрической печи, хромель-алюмелевой термопары и электронного потенциометра.

Экспериментальные исследования показывают, что плотность жидкого стекла существенно влияет на его коэффициент вспучивания. Жидкое стекло с плотностью 1,64 г/см^3 имеет коэффициент вспучивания 60, с плотностью 1,3 г/см^3 - 20, с плотностью 1,1 г/см^3 - 4. Для получения термостойких покрытий ма лярной консистенции использовалось жидкое стекло с плотностью 1,3 г/см^3. С целью улучшения физико-механических, специальных свойств силикатного связующего в его состав вводились тонкодисперсные и волокнистые минеральные наполнители рис. 1, рис. 2, рис. 3. Установлено рис. 1, что введение тонкодисперсных минеральных наполнителей увеличивает среднюю плотность силикатного связующего на 20-30 %, а волокнистого наполнителя на 2,0-15,0 %.

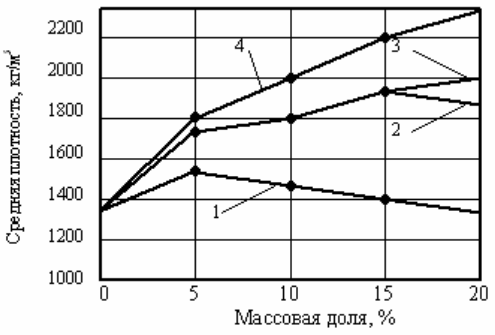

Рис. 1. Влияние процентного содержания минеральных наполнителей на среднюю плотность силикатного связующего в естественных условиях.
1 – минеральная вата; 2 – мел; 3 – трепел; 4 – зола.

Введение минеральных тонкодисперсных и волокнистых наполнителей в количестве от 10 до 20 % приводит к увеличению прочности (рис. 2). Трепел, зола, мел увеличивают предел прочности силикатного связующего в 2÷4,5 раза. Максимальная величина прочности получена при введении 20 % трепела. Введение волокнистого наполнителя в количестве 10-20 % увеличивает прочность композиции в 2 раза.

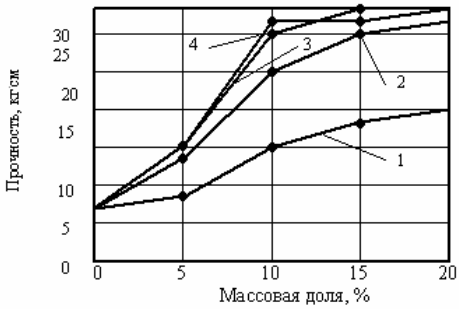

Рис. 2. Влияние минеральных наполнителей на прочность силикатного связующего.
1 – минеральная вата; 2 – мел; 3 – трепел; 4 – зола.

Анализ полученных зависимостей показывает, что введение золы и мела приводит к уменьшению коэффициента вспучивания, а введение трепела и волокнистого наполнителя увеличивает коэффициент вспучивания на 20-25 % (рис. 3). Дальнейшее увеличение количества вводимого трепела и волокнистого наполнителя в состав силикатного связующего приводит к снижению коэффициента вспучивания, но его величина даже при 20 % содержания трепела выше коэффициента вспучивания жидкого стекла.

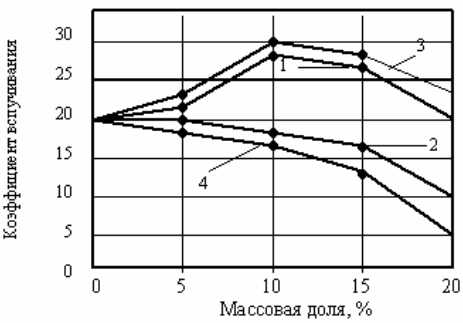

Рис. 3. Влияние минеральных наполнителей на коэффициент вспучивания силикатного связующего
1 – минеральная вата; 2 – мел; 3 – трепел; 4 – зола.

Увеличение коэффициента вспучивания при введении трепела объясняется ее химическим составом, т.к. являясь аморфной формой кремнезема, трепел испаряет свободную и химически связанную воду, способствуя вспучиванию силикатного связующего. Трепел и минеральная вата увеличивают коэффициент вспучивания силикатного связующего до температуры равной 400°С. Образующийся пенококс не уменьшается по объему до температуры

600°С, а затем наблюдается его выгорание и разрушение.

С целью стабилизации пенококса в состав данной композиции вводились фосфатный антипирен и пигмент реагент. Данные дифференциальнотермического анализа в сочетании с рентгенофазовым анализом показывают, что в диапазоне температур 120÷600°С вспучивание системы идет за счет термических превращений: дегидратация и взаимодействия отдельных компонентов. При температуре 600°С начинается образование новой составляющей композиции – альбита.

Это приводит к образованию прочного вспененного слоя невыгорающего при температуре 600°С.

Результаты проведенных исследований доказывают возможность использования горных пород в качестве исходного сырья для получения вспучивающихся термостойких покрытий по металлу. Данные исследования являются составной частью научных работ по разработке универсальной рецептуры ВТП специального назначения для строительных, дорожных и технологических машин.

ЛИТЕРАТУРА:

1. Брушлинский Н.Н., Соколов С.В. Проблема пожаров в мире в начале XXI столетия. Пожаровзрывобезопасность. – 2003. - №1. – С. 7-14.
2. Тадасиге К., Хидзе И. Огнестойкие краски. Тосо то торё, 1971, №201, с. 167-172.
3. Vandersall H.L. J. Firea Flam 1971. V.2. April, P. 97-100.
4. Романенков И.Г., Левитис Ф.А. Огнезащита строительных конструкций. Стройиздат, М., 1991, 350 с.

GENERAL ASSOCIATION OF SNOW MASS' MELTING'S TIME UNDER ACTION OF THE ELECTRIC ENERGY

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Abstract

In the article problems of salvaging of snow mass are considered at removal urban streets in the winter season. Outcomes of laboratory probes of private(individual) relations of snow mass' melting's time from such factors, as voltage on current electrodes, weight fraction of components of snow mass, environmentional temperature, distance between current electrodes are submitted. The general relation of snow mass' melting's time from listed factors is offered. Ways of operational use of outcomes of activity are considered. The capability of development and use of snow melters of type is marked.

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Key words: *electric energy, snow melter, snow mass, current electrodes, semiportable type of snow melters.*

USING AN ELECTRIC ENERGY FOR SALVAGING SNOW MASS

Recently rather new method of salvaging of the snow gathered from urban streets - devices for melting a snow intensively explicates.

The analysis of devices for salvaging snow mass has shown, that the philosophy of their action this water saturation of the acting snow mass by means of warm water given from exterior sources, stirring of received snow porridge before practically complete melting and waste interception of the formed water in open pools. Has been solved to develop essentially new mode of melting of snow mass up to a condition required at salvaging.

The hypothesis about a possibility of use in considered process of disposableer and general-purpose power - electrical has been put forward. At what not at the expense of heating any conductor, and at the expense of heating and melting of a snow, as conductor of a current flow. At first sight such it is not possible basically as the snow is one of modular condition of water which in a clear condition is a dielectric. But in a clear condition, and the snow mass collected from streets of cities, represents the certain disperse system consisting of three basic elements:

1) Immediately snow-and-ice particles and free water;
2) Fluid chemical and salt component reagents;
3) Parts of a ground, injected it is synthetic at extirpation with glazed frost, or hitted in the collected mass at sanitation of a road bed and transportation.

Application of electrical power for partial melting snow mass will allow to manufacture its humidification at the expense of inner resources of a snow, not applying water which transportation is power-intensive enough process.

DETERMINATION OF PRIVATE ASSOCIATIONS

Factors of a variation at different stages of experiment are specific:

T_{OKP} - environment temperature, in $°C$;

S, G, H - components of snow mass, in fractions of total mass;

U - voltage on current electrodes, in V;

t - operate time of a current, in sec;

L - distance between current electrodes, in cm.

Definition of association of time of melting of a sample from a voltage on current electrodes. The objective analysis shows, that on small currents melting of samples is impossible, and on major currents time of melting is faded out.

In this connection a guessed aspect of association - logarithmic, or exponential.

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The regression - correlation analysis which has been carried out in program TableCurve, has shown, that to received experimental data association of an aspect (1) has the greatest approximating.

$$y = C_0 + C_1 \cdot \ln(x) \qquad (1)$$

as C_0, C_1 - constants.

At account of regression coefficients the apparent aspect of association for initial{starting} stationary values of requirements ($T_{окр} = -1°C$; a clear snow) has been received.

$$t(U) = 996 - 130 \cdot \ln(U) \qquad (2)$$

Pictorial map of received association is introduced on fig. 1.

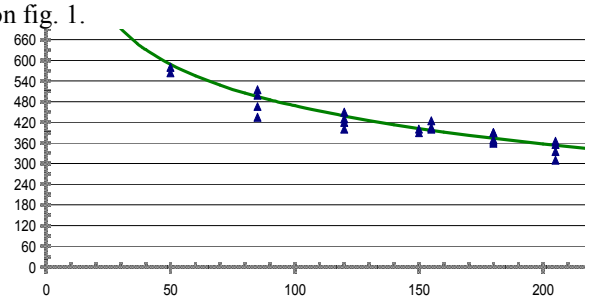

Fig. 1. Association time of melting of a laboratory sample of snow mass (sec) from a voltage on current electrodes (V)

Definition of association of time of melting of a sample from weight fraction of components of snow mass. It is unconditional, there is an effect of the contents of ingredients of snow mass for the period of melting a sample, that potentially can affect efficiency of a considered method.

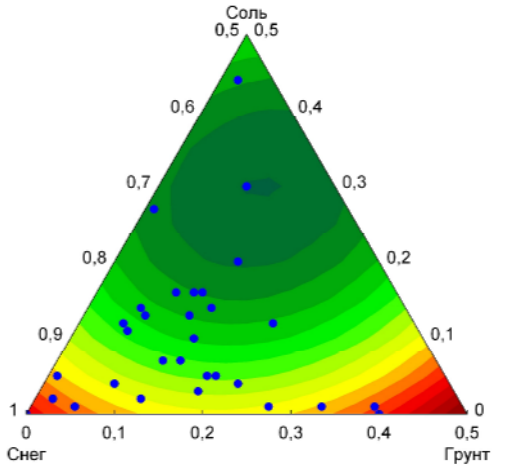

Fig. 2. An arrangement of experimental data on the contour graph of a figurative surface of association of time of melting of a sample from weight fraction of components of snow mass

Having assumed, that the form of association is analogous to effect of weight fraction of components of snow mass on specific electrical resistance of a sample, experimental data with the purpose to clarify regression coefficients have been processed and to define an apparent aspect of association.

In connection with that research problems do not guess a determination of a precise aspect of association of function at small volumes of the contents of a snow, the majority of experimental samples was in limits of fifty and more percentage of a snow. For what limitations have been injected into a figurative frame of axes. The arrangement of weight fraction of components of snow mass in a contour figurative field with injected limitations is introduced on fig. 2.

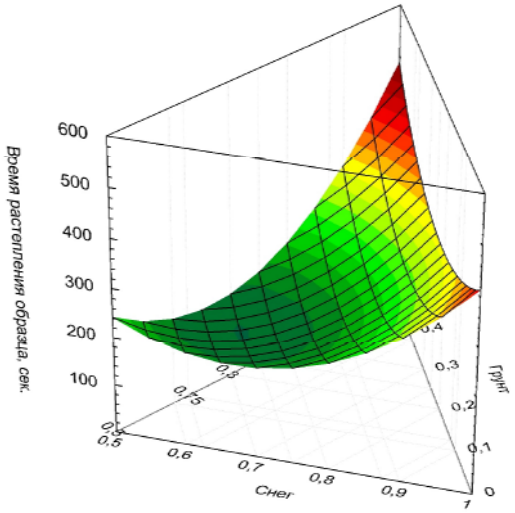

Fig. 3. Association of time of melting of a sample (sec) from weight fraction of components of snow mass

Integral three-factor association of process after an evaluation of regression coefficients looks like:

$$t(G,H,S) = 372{,}8 \cdot H + 2068{,}5 \cdot G + 360{,}5 \cdot S - \\ - 2196{,}2 \cdot H \cdot G + 746{,}4 \cdot H \cdot S - 1725{,}7 \cdot G \cdot S; \qquad (3)$$

Pictorial map of received association in volumetric triangular coordinates is introduced on fig. 3.

Definition of association of time of melting of a sample from environment temperature. The factor circumscribing effect of exterior natural factors, in considered process environment temperature is. Therefore its effect for the period of melting a sample is necessary for taking into account, as causes requirements to a determination of association of time of melting of a sample from environment temperature.

On considered temperature range of an environment in a general view it is possible to introduce association of time of melting of a sample on this factor the exponential law.

After account of regression coefficients association looks like the following:

$$t(T_{OKP}) = 355{,}25 \cdot e^{-0{,}05 \cdot T_{OKP}}; \qquad (4)$$

Pictorial map of association is introduced on fig. 4. It is necessary to mark, that on temperature range up to a minus 10 °C melting of samples up to a condition of collapse during 600 seconds was not observed. And at the considerable overflow in temperature of a mark 0 °C

(especially after 5-10 °C) melting of a sample happens any more so much at the expense of action of a current flow, how many at the expense of natural melting a snow.

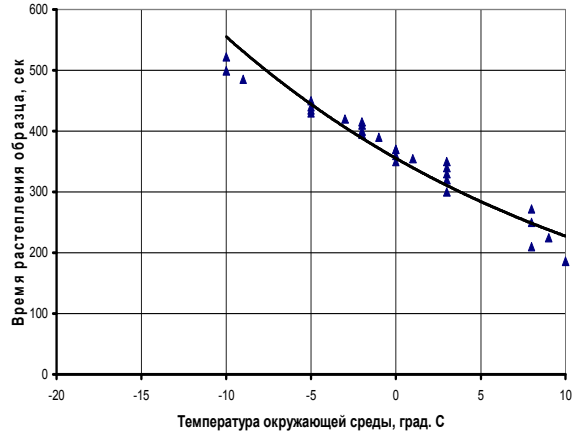

Fig. 4. Association of time of melting of a sample (sec) from environment temperature (°C)

Definition of association of time of melting of a sample from distance between current electrodes. For designing and account of a critical parameters of snow melters it is necessary to take into account effect of constructional parameters of a method for the period of melting a sample. The essential factor to which can describe the given effect, the distance between current electrodes (L) serves. However the variation of this factor guesses change of volume of a sample and, accordingly, change of mass of a sample.

Meanings of time of melting of samples were fixed, data's registering experiment.

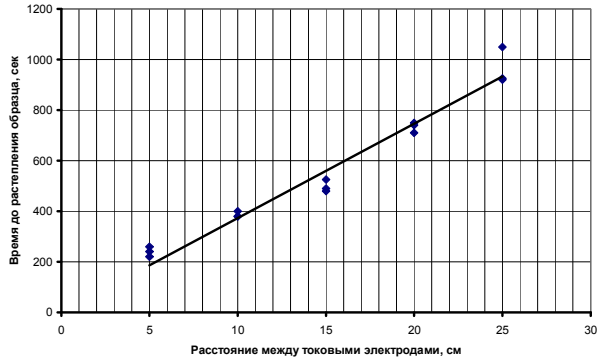

Fig. 5. Association of time of melting of a sample (sec) from distance between current electrodes (cm).

Variation of meanings of distance between current electrodes it was made in limits of the following discrete magnitudes: 50, 100, 150, 200, 250 mm.
It is possible to introduce a general view of association as a polynomial of the first degree, as adequate which pictorial interpretation the straight line serves:

$$y = C_0 + C_1 \cdot x; \qquad (5)$$

After account of regression coefficients association looks like the following:

$$t(L) = 37{,}33 \cdot L; \qquad (6)$$

as L - in centimeters.

Pictorial map of association is introduced on fig. 5. All private associations are characterized by high-scale of adequacy.

DETECTION OF COMMON ASSOCIATIONS.

As a matter of convenience uses of a mathematical means to exposition of conduct of snow mass under action of a current flow it is necessary to make common mathematical model which would affect effect of a complex of factors. Therefore the output of common mathematical model from private associations is required.
Necessity of carrying out of such accounts has been stipulated at planning experimental searches that has stipulated a choice of original parameters of probes.
At the first stage incorporation of associations of factors surveyed above for the period of melting a sample was made. Having introduced each association as (7), it is possible: at first, to define objectivity of the suggested associations, determining a stationary value of association for fixed initial conditions; second, to take out for a mark of function a stationary value for data's of initial conditions magnitude.

$$t(x) = t_0 \cdot f(x); \qquad (7)$$

as t_0 - time of melting of a sample in "zero" requirements - a stationary value for fixed initial conditions magnitude; $f(x)$ - function agency of the concrete factor for the period of melting a sample.
The possibility of a determination of common association in such a way speaks a small degree of interference of factors. According to data's of experiment, it is possible to reveal the requirements accepted for original, at a determination of a stationary value component.
Thus, at reduction of private associations in common mathematical model according to the formula (7):

$$\begin{aligned} t &= f(U;T_{OKP};L;H;G;S) = \\ &= t_0 \cdot f(U) \cdot f(T_{OKP}) \cdot f(L) \cdot f(H;G;S) = \\ &= 373{,}3 \cdot \left(2{,}67 - 0{,}35 \cdot \ln(U)\right) \cdot \left(0{,}95 \cdot e^{-0{,}05 \cdot T_{OKP}}\right) \cdot \left(0{,}1 \cdot L\right) \cdot \\ &\cdot \left(H + 5{,}54 \cdot G + 0{,}97 \cdot S - 5{,}88 \cdot H \cdot G + 2 \cdot H \cdot S - 4{,}62 \cdot G \cdot S\right); \end{aligned} \qquad (8)$$

The given association features agency of all significant factors surveyed during probe for the period of melting a sample of a snow in original firmness of 0,3 т/m^3 and, accordingly, in mass 75 g.

Time of melting n kilogram of snow mass:

$$\begin{aligned} t &= f(U;T_{OKP};L;H;G;S;n) = \\ &= 373{,}3 \cdot \left(2{,}67 - 0{,}35 \cdot \ln(U)\right) \cdot \left(0{,}95 \cdot e^{-0{,}05 T_{OKP}}\right) \cdot \left(0{,}1 \cdot L\right) \cdot \\ &\cdot \left(H + 5{,}54 \cdot G + 0{,}97 \cdot S - 5{,}88 \cdot H \cdot G + 2 \cdot H \cdot S - 4{,}62 \cdot G \cdot S\right) \cdot \frac{n}{0{,}075}; \end{aligned} \qquad (9)$$

The picture representation of introduced total associations complicates in view of major number of factors, therefore visual introducing about agency of that, or other factor it is possible to receive only on private associations. However mathematical expressions of common associations represent the considerable interest, as at designing and selection of mode of behaviors of snow melters, and for exposition of process of melting of snow mass under action of the electric energy.

APPLICATION OF OUTCOMES OF OPERATION.

The detected associations allow further a carry designing of snow melters on the basis of the suggested mode. Application of the suggested associations probably by development of a procedure of moisture determination of snow mass.

Taking into consideration hazard of ac operation of a high voltage at transferring a snow in an aqueous phase, it is necessary to give special attention to requirements of electrical safety.

Snow melters of electrical type can be referred to electroheat installations which maintenance operation the electrotechnological personnel should realize. Duties of the electrotechnical and electrotechnological personnel should be separate when due hereunder. It is necessary to provide a system of protective automatics with the purpose of switching-off of feeding of a current flow on electrodes at a short-circuit between electrodes.

The attention a possibility of development and use of snow melters to a floor of stationary type pays to itself. To a floor stationary snow melters can be builted in the beginning of a winter season in served territory, and at the end of a season to be disassembled and relocated on basis of a storage. Compactness of such snow melters will allow to lower expenditures on carriage of a snow from a place of assembly to plant of salvaging and will stipulate a possibility of their use not only for melting snow mass from urban streets, but also a snow collected in domestic territories.

The basic advantages of such type of snow melters should be:

1. A possibility of change of the location depending on amounts of works;
2. Sufficient compactness at a necessary velocity of salvaging.

Making of compact snow melters will help to provide cutting-down of hauling charges on carriage of a snow, and as a salvageability of small volumes in short terms.

THE LAW OF THE LIVING MATTER CONSTANT
(the sixth Ecoman law)

Radivoje Djurin Mančić [1], Dragan J. Gavrilović[2]

Resume: The process of urbanization must sustain the living matter constant. This law was derived from five basic Ecoman laws and from Odum's law, applied in urban ecology, regulating relation between continually built areas at 40 percent, to urban green areas of 60 percent, on which biomass is produced. The sixth Ecoman law has significant use in deciding on the degree of urbanization and the rate of area usage in the continually built area. The law of the living matter constant is another term for the sixth Ecoman law which is recommendedto be used in urban engineering.

Key words: Odum's law, urban-ecological systems

INTRODUCTION

The end of the second millennium of new era passes in affirmation of urban ecology, in new architectonic-urbanism, scientific discipline whose theoretic basis consists of principles, rules and laws of ecological balance. Thus Odum's law is implemented and applied in architectonic-urbanism science, finds the place and implementation of Odum's law (1.,160). The Odum's law gives the relation between the rate of yield (fecundity), depending on ecological, social and economic effects in spatial relations with natural spatial characteristics which are changed by human acting (fig. 1).

THE URBAN AND ECOLOGICAL INTERPRETATION OF THE ODUM'S LAW

The Odum's law applied in urban ecology regulates the relation between continually built areas (urban areas) and areas with biomass (the total amount of green areas in a town). From this interpretation of the Odum's law the sixth Ecoman law was developed stating the following: towns architecture must conserve the amount of living matter on the earth .

Architectonic and urbanism science in the twenty-first century is based on the law of constant amount of living matter in the precise geological era (V.I. Vernadskij,129). Technical and technological development of civilization in the twenty-first century changes cognition about length of duration of a civilization period, so that the twenty-first century must be considered as new, the third era in social and civilization sense, substantially different from previous era. The beginning of the twenty-first century has the character of new era in global natural and geographic meaning, too (the ozone holes have already defined the new era).

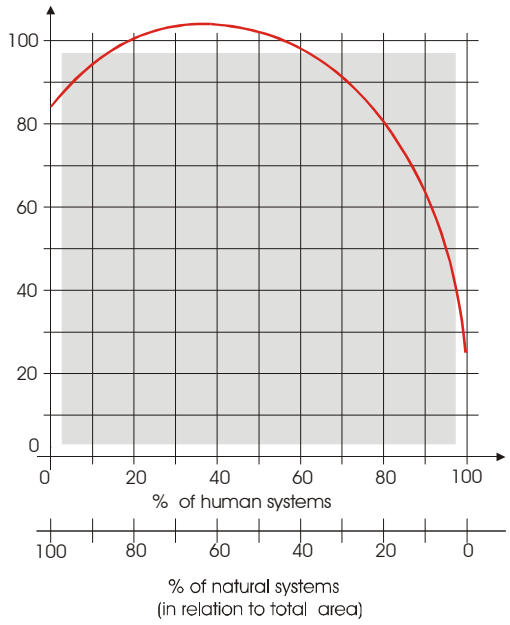

Fig. 1. Odum's law graph.

The third era from geographic,climate and energetic aspect brings new material and energetic phenomena, processes and relations in architectonic and urbanism functional design and materialization. For life survival on the earth, for urbanization of the twenty first century, we should find (considering the Vernadsky's law of the constant matter), the new relation between the amount of biomass and the earths material potential, which will suit

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the planning degree of built and the degree of used space.
The process of urbanization so far has meant the reduction of the earth's biomass. The law of biomass constant demands the constant level of biomass on the earth, that is if there is a decrease of the biomass amount on one area there must be the increase of the biomass amount on another area. Up to now the process of urbanization has devastated the earth's biomass, and the biomass has not been produced on the same rate on some other places.
In theoretical basis of architectonic and urbanism science in the twenty-first century the principles, rules and laws of ecological balance are implemented. The basics of the optimality principle are formulated as optimal energy consumption necessary to sustain present level of life in an urban system and ability of the system to resist chaotic tendencies with the minimum energy spent. The implementation of the Odum's law means bringing to an end the rule of technologies and introducing the basic biological principles into the process of development and reconstruction of towns. It is necessary to implement biological laws in projecting urban areas because towns are habitation places of humans which are biological creatures.
Architectonic and urbanism concept of continually built areas must undergone the principle change in the twenty-fist century: The Odum's total ecological, social and economic effect implemented on urban areas, needs the following relations: 40 % of constructed areas and 60 % of natural ecosystems with the condition that green urban areas must be created with 100 % of natural arrangement. Only that kind of space could be potential carrier of the characteristic of ecological efficiency. The Odum's law is in direct relation with the degree of built and the degree of usage of continually built space.
In table 1 there is synthesis of gradation analysis of solar impact factors, which follow the degree of built urban block. The gradation has five categories from 15 to 30 percent of built. Along with the decrease of the degree of built there is the increase of solar accumulation, radiation, evaporation and ventilation as well as decrease of the shadow factor. The result which could be apply for the solar characteristics of a block, depend of the degree of built is the factor of (Si_{sol}) whose value moves from 2.63 for the first category (Si_1), to 3.72 for the fifth category (Si_5). The evaluation of the degree of built is given in the range from 0.2 to 1.0, and is used for ecological evaluation of a project. (R. Mančić and D. Gavrilović on the Architecture faculty in Pristina, from 1994 to 1996 investigated the models for the degree of built and the degree of urban block usage by the effects of the sixth Ecoman law and found the results which withstood ten years of practical review).

THE SOLAR EFFECTIVENESS OF THE DEGREE OF LAND USAGE [Sk]

In urban and ecological gradation of the degree of land usage of an urban block, as the ratio between the totally developed architecture land with the total block area, whose ratio is in the interval between 0.4-1.2, one can notice: as the values of the **Sk** coefficient increase, the size of the object also increases, and the areas for the energetic absorption and emission also increase. From this follows that the impact of such space configuration is more sensible to energetic flows of exchange with the environment. In the same time the Sk coefficient has bigger impact on the microclimate change in an urban block, as well as the creation of internal air streams.
For the degree of land usage (Sk_n), it is begun from the division on five categories of the degree of land usage, from Sk_1=1.2 for the first group, to Sk_5=0.4 for the fifth group.
With the increase of the degree of land usage there is also the increase the values of coefficients of accumulation, radiation and shadow, and the values of coefficients of evaporation and ventilation decrease. Because of this contrast, with approximately the same absolute values but with opposite sign compared to the value of the coefficient Sk_n, we obtain relatively small changes of the solar factor of the degree of usage (Sk_{sol}), which moves in interval from 3.24 for Sk_1 to 3.32 for Sk_5. The evaluation of value is given in the range from 0.2 for Sk_1 to 1.0 for Sk_5.
In figure 2, the graphic interpretation of functional distribution of coefficients of importance for maximal absorption of passive solar radiation is given, for different variants of the usage of land in an urban block. From the graphic interpretation one can notice that the impact of solar shadow for the fifth level (Sk_5) has the minimum value while for the first level (Sk_1) it has maximum value. Accumulation and radiation factors act on the similar way, while the factors of evaporation and ventilation have different course. The deployment of the sixth Ecoman urban and ecological law is based on the principles of openness, optimality and self regulations of the urban systems.

THE ENERGY, THE MATTER FLOW, PRODUCTIVITY AND PROFITABILITY OF URBAN-ECOLOGICAL SYSTEMS

Material and energy flows between neighboring settlements and a city are completely unilateral, from a smaller to a bigger settlement. 90 % of material flows is directed to a city while 10 % flows from a city to neighboring settlement. This is the implementation of the energy pyramid's law, which is formulated by R. Lindeman [N R.,103]. According to the energy pyramid's law, the energy from one level of ecological pyramid flows to another, higher than previous one, averagely about 10 percent of the energy that is accumulated on the previous level. The reverse flow, in conjunction with the matter produced on the higher level of ecological pyramid, is much smaller and its value is no more than 0,5% (even 0,25%) of total amount of energy. N.Rejmers [,104] finds that, if energy is ten times more wasted in transition from lower to higher level of the ecological pyramid, in the same time the concentration of pollutants is ten times higher in the higher level.

If a town is observed as an open system, according to "sustain arrangement" (according to I.R. Prigožinu [N.R.,54]) the entropy will not increase but decrease, until the minimum is reached.

Table 1. The categorization of the degree of built of an urban block with matched solar dependant factors.

Kind of activity	The categorization of the degree of built				
	SI_1	SI_2	SI_3	SI_4	SI_5
Accumulation	0.45	0.56	0.67	0.78	0.90
Radiation	0.48	0.59	0.70	0.81	0.92
Evaporation	0.60	0.67	0.75	0.83	0.90
Ventilation	0.40	0.52	0.65	0.77	0.90
Shadow	0.70	0.55	0.40	0.25	0.10
Solar factor of degree of built Si_{sol}	2.63	2.89	3.17	3.44	3.72
Evaluation of value	0.2	0.4	0.6	0.8	1.0
The engagement percentage	30%	25%	20%	15%	10%

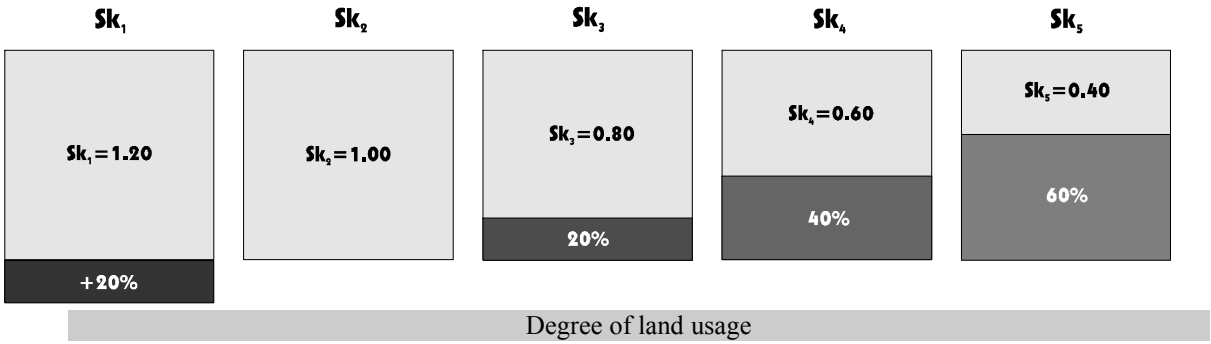

Fig. 1. Decomposition variants of the degree of land usage of an urban block .

Table 2. The categorization of the degree of built of an urban block with matched solar dependant factors.

Kind of activity	The categorization of the degree of built				
	Sk_1	Sk_2	Sk_3	Sk_4	Sk_5
Accumulation	0.90	0.85	0.80	0.75	0.70
Radiation	0.94	0.88	0.82	0.76	0.72
Evaporation	0.45	0.56	0.67	0.79	0.90
Ventilation	0.25	0.41	0.57	0.74	0.90
Shadow	0.70	0.55	0.40	0.25	0.10
Solar factor of degree of usage Sk_{sol}	3.24	3.25	3.26	3.29	3.32
Evaluation of value	0.2	0.4	0.6	0.8	1.0

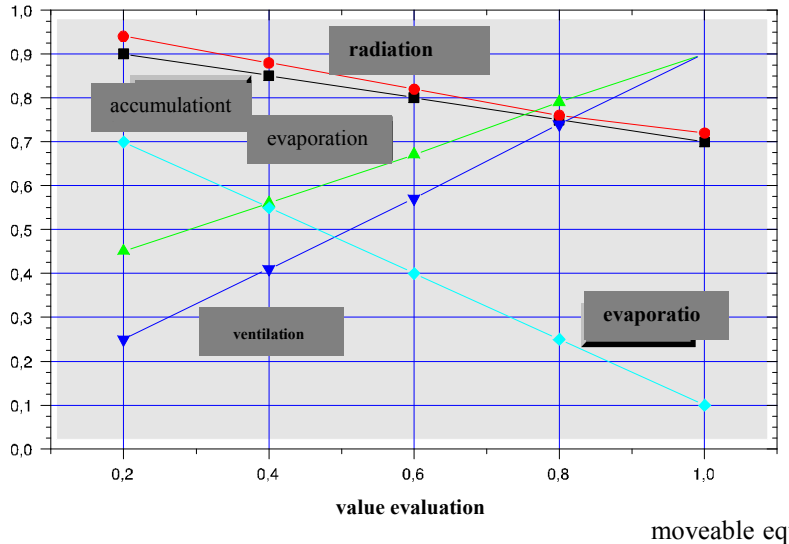

Fig. 2. Functional distribution

The elements of the settlement under the influence of this theorem disposes in the manner that in some elements the entropy increases, in others notably decreases, while a town does not lose the arranged property. Human activity never produces entropy, because it always keeps the systematization property, humans always accommodate themselves to new surroundings, they keep individuality in development and have the role of factors that form environment characteristics. The majority of the systems that urban ecology meets does not produce entropy.

Big cities are similar to dinosaurs, whose huge amount of matter and energy is spent for sustaining of big mass (city's biomass) and huge number of information required for preserving the city's spiritual life.

CONCLUSION

Urban science must obey the universal law under which whole world functions with the aim to preserve life on the earth. The self regulation mechanism at population level of biosphere does not depend on human practice. If architecture science does not find the laws for ecological city development, as a community where natural laws rule, the danger state of natural laws neglecting can come. The human activities from the first urban revolution to the end of the twentieth century, has modified biocenosis and significantly changes homeostasis at the cenosis level, but still the level of global change has not brought to the life modification or to the life disappearing. The group of laws under which the self regulation takes place, have as consequence that every population supports its environment. The unlimited cities enlargement or enlargement of their parts, complicates preservation of the system's moveable equilibrium and destroys optimal functioning. The city systems will keep on functioning, but under the huge consumption of energy and matter, which is opposite to global ecological goals in development of a city, settlement or regional town systems or other settlements. Not long time ago the architectonic and urbanism science theoreticians claimed that urban systems do not posses their own equifinality, and there are no fix boundary between the growth and the final state of the system. However, the deeper support of architectonic and urbanism science on biological laws, produces the attitude that a city has its own optimal dimensions and optimal land usage density and land built after overgrowing of these values the physiological changes of system life take place. There is desirable state of the system which corresponds to geological era in which the relation between human and natural is precisely settled.

REFERENCES

1. Rejmers N.F. ″ Nadeždi na vyživanie čelovečestva konceptualna ekologija″, Moskva 1992.
2. Mančić R. ″ Industrijski objekti i urbanizacija″, Ekoman, Niš 1996.
3. Dimitrijević J. ″Nove metode za ocenu efikasnosti zaštite životne sredine u urbanim prostorima″ Disertacija, FZNR Niš,1991. god.
4.Mančić R. ″ Fundamental′nie zakkony ekologii goroda″, International conference ″Predupreditel′nij inženering i okružajuščaja sreda″ Niš 1995.
5. D.Gavrilović, " primena pasivnog solarnog zahvata u urbanisti;kom planiranju" GAF Priština,1996 (Phd thesis).

THE MODEL FOR DETERMINATION OF THE TEMPERATURE AND THE GAS COMPOSITION OF BIOMASS GASIFICATION PRODUCTS BY THE USE OF MATERIAL AND ENERGY BALANCES

Vladan Karamarković [1], Miljan Marašević, Rade Karamarković

Abstract:
The paper presents the model for the analytical determination of the temperature and the gas composition of biomass gasification products in downdraft gasification reactors at atmospheric pressure. The temperature and the gas composition were determined by the use of material and energy balances.
Key words: *biomass, gasification, gasification temperature.*

INTRODUCTION

The main disadvantage of the existing models for prediction of downdraft gasification gas composition is only applying the material balance equations. Analytically gained results for the temperature and the gas composition by the use of material balance equations are acceptable only for the precise relation between moisture content of the biomass and the amount of carbon that is used as a heat source for occurring of gasification reactions, apropos for the definite heat loss through sensible heat of gasification products.
The model modification, presented in this paper, is done by applying the equation of energy balance and the homogeneous reversal equation:

$$CO_2 + H_2 \Leftrightarrow CO + H_2O$$

MODEL FOR DETERMINATION OF THE BIOMASS GASIFICATION TEMPERATURE

The assumption made for determination of the temperature and the gas composition of biomass gasification products is that in the reduction zone of downdraft gasification reactor these reactions take place:

$$C + 2\,H_2 \Leftrightarrow CH_4 \quad (1.1)$$
$$C + CO_2 \Leftrightarrow 2\,CO \quad (1.2)$$
$$C + H_2O \Leftrightarrow CO + H_2 \quad (1.3)$$
$$CO_2 + H_2 \Leftrightarrow CO + H_2O \quad (1.4)$$

The difference between this and other models is that this model includes the fourth homogeneous reaction (1.4).

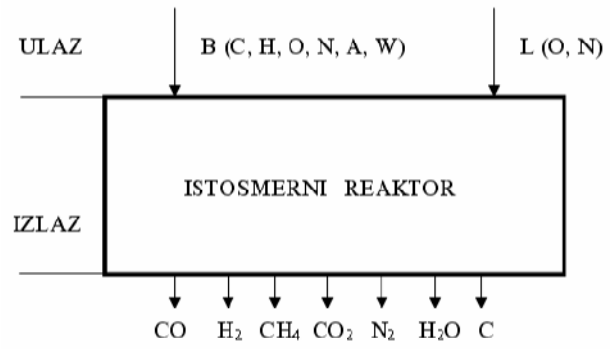

Figure 1.1. Downdraft reactor scheme

B (kg) – the amount of the fuel that enters in the reactor
W (kg/kgB) – the moisture content of the fuel
L (kg/kgB) – the amount of air that enters in the reactor
X_{CO}, X_{H2}, X_{CH4}, X_{CO2}, X_{N2}, X_{H2O}, X_C (kmol/kmol) – the mole fractions of the reactions products at the equilibrium mixture.
This is a complex mathematical problem that requires solving the system of eight equations with eight unknowns. The seven unknowns are the mole fractions (X_{CO}, X_{H2}, X_{CH4}, X_{CO2}, X_{N2}, X_{H2O}, X_C) and the eighth is the gasification temperature.
The additional assumption, which states that whole amount of the biomass hydrogen, is used as the heat source for the reactions in the reduction zone is introduced.

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The chemical equilibrium constant of the assumed homogeneous reaction (1.4) depend on temperature, and is determined with equation:

$$\log K_4 = 1.6945 - \frac{1855.6}{T} \qquad (1.5)$$

Determination of the gas composition and the gasification temperature is done for the different values of fix carbon that comes into the reduction zone, and for the different biomass moisture content.

The equations for determination of the mole fractions in equilibrium mixture and the temperature of biomass gasification are:

$$X_{CO} + X_{H_2} + X_{CH_4} + X_{CO_2} + X_{N_2} + X_{H_2O} + X_C = 1 \quad (1.6)$$

$$\frac{\sum O_2}{\sum H_2} = \frac{\frac{1}{2}\cdot X_{CO} + X_{CO_2} + \frac{1}{2}\cdot X_{H_2O}}{X_{H_2} + 2\cdot X_{CH_4} + X_{H_2O}} = A \qquad (1.7)$$

$$\frac{\sum C}{\sum N_2} = \frac{X_{CO} + X_{CO_2} + X_{CH_4} + X_C}{X_{N_2}} = \frac{1}{B} \qquad (1.8)$$

$$\left(12635\cdot X_{CO} + 10785\cdot X_{H_2} + 35880\cdot X_{CH_4}\right)\cdot \left(\frac{\frac{22.4}{12}\cdot\left(C - C_g\right)}{12\cdot\left(X_{CO} + X_{CO_2} + X_{CH_4}\right)}\right) = H_{dB}\left(1 - q_g\right) \qquad (1.9)$$

$$K_1 = \frac{X_{CH_4}\cdot\left(1 - X_C\right)}{p\cdot X_{H_2}^2} \qquad (1.10)$$

$$K_2 = \frac{p\ X_{CO}^2}{\left(1 - X_C\right)\cdot X_{CO_2}} \qquad (1.11)$$

$$K_3 = \frac{X_{CO}\cdot X_{H_2}\cdot p}{X_{H_2O}\cdot\left(1 - X_C\right)} \qquad (1.12)$$

$$K_4 = \frac{X_{CO}\cdot X_{H_2O}}{X_{CO_2}\cdot X_{H_2}} \qquad (1.13)$$

The dimensions in the above equations of material and energy balances are:

C_g $\left[\frac{kJ}{kgB}\right]$ - the mass fraction of carbon in the ash

q_g $[\%]$ - the entire heat loss through sensible heat, and conduction and radiation

H_{dB} $\left[\frac{kJ}{kg}\right]$ - the biomass heating value.

$$H_{dB} = 33900\cdot C + 117000\cdot\left(H - \frac{O}{8}\right) - 2500\cdot W \qquad \left[\frac{kJ}{kg}\right]$$

- The amount of carbon:

$$\sum C = \frac{1}{12}\cdot C \quad \left[\frac{kmolC}{kgB}\right]$$

- The amount of oxygen:

$$\sum O_2 = \frac{1}{32}\cdot\left(\frac{16}{18}\cdot W + \frac{8}{3}\cdot R\cdot C + 8\cdot H\right) \quad \left[\frac{kmolO_2}{kgB}\right]$$

- The amount of hydrogen:

$$\sum H_2 = \frac{1}{2}\cdot\left(H + \frac{1}{9}\cdot W\right) \quad \left[\frac{kmolH_2}{kgB}\right]$$

- The amount of nitrogen:

$$\sum N_2 = \frac{1}{28}\cdot\left(N + \frac{77}{23}\cdot\left(\frac{8}{3}\cdot R\cdot C + 8\cdot H - O\right)\right) \quad \left[\frac{kmolN_2}{kgB}\right]$$

In equations (2.6), (2.8), (2.10), (2.11) and (2.12) there is unburned carbon (Xc). The equations are derived on this way:

$$X_{CO} + X_{H_2} + X_{CH_4} + X_{CO_2} + X_{N_2} + X_{H_2O} + X_C = 1 \quad (1.14)$$

$$\frac{X_{CO}}{1 - X_C} + \frac{X_{H_2}}{1 - X_C} + \frac{X_{CH_4}}{1 - X_C} + \frac{X_{CO_2}}{1 - X_C} + \frac{X_{N_2}}{1 - X_C} + \frac{X_{H_2O}}{1 - X_C} = 1$$

$$p\frac{X_{CO}}{1 - X_C} + p\frac{X_{H_2}}{1 - X_C} + p\frac{X_{CH_4}}{1 - X_C} + p\frac{X_{CO_2}}{1 - X_C} + p\frac{X_{N_2}}{1 - X_C} + p\frac{X_{H_2O}}{1 - X_C} = p$$

According to Dalton's law:

$$p_{CO} + p_{CO_2} + p_{H_2} + p_{H_2O} + p_{CH_4} + p_{N_2} = p \qquad (1.15)$$

By using the partial pressures determined in the equation (1.14), the equilibrium constants of chemical reactions can be calculated by following equations:

$$K_1 = \frac{P_{CH_4}}{P_{H_2}^2} = \frac{X_{CH_4}\cdot\left(1 - X_C\right)}{p\cdot X_{H_2}^2}$$

$$K_2 = \frac{P_{CO}^2}{P_{CO_2}} = \frac{p\ X_{CO}^2}{\left(1 - X_C\right)\cdot X_{CO_2}}$$

$$K_3 = \frac{P_{CO}\cdot P_{H_2}}{P_{H_2O}} = \frac{X_{CO}\cdot X_{H_2}\cdot p}{X_{H_2O}\cdot\left(1 - X_C\right)}$$

$$K_4 = \frac{X_{CO}\cdot X_{H_2O}}{X_{CO_2}\cdot X_{H_2}}.$$

The equilibrium constants K_1, K_2, K_3, and K_4 of the chemical equations were determined by laboratory measurements, when the full equilibrium was reached (homogeneous temperature, pressure, and concentration fields after sufficient reaction time). These conditions can not exist in a real process.

The system of equations was solved by the software MATLAB R12, and the results are illustrated on the figures (1.2), (1.3) and (1.4).

TABLE 1.1 GAS COMPOSITION

Gasification temperature (^{0}C)		703	681	662	645	630	615
The amount of injected moisture W_1(kg/kgB)		0.25	0.25	0.25	0.25	0.25	0.25
The amount of burned carbon R		0.36	0.36	0.36	0.36	0.36	0.36
Heat loss J		0.05	0.08	0.11	0.14	0.17	0.2
Gas composition	xCO(%)	24.36	22.26	19.63	17.84	15.79	13.66
	xH_2(%)	19.00	19.11	18.81	19.13	19.01	18.49
	xA(%)	0.19	0.13	0.63	0.005	0.15	0.34
	xCH_4(%)	0.45	0.60	0.78	0.95	1.14	1.33
	xCO_2(%)	5.39	7.18	8.82	10.61	12.13	13.18
	xH_2O(%)	2.73	3.68	4.57	5.68	6.76	7.77
	xN_2(%)	27.88	27.04	26.76	25.78	25.02	25.23
	xW_G(%)	20.00	20.00	20.00	20.00	20.00	20.00

TABLE 1.2 GAS COMPOSITION

Gasification temperature (^{0}C)		719	701	687	675	663	653
The amount of injected moisture W_1(kg/kgB)		0.1	0.15	0.2	0.25	0.3	0.35
The amount of burned carbon R		0.35	0.35	0.35	0.35	0.35	0.35
Heat loss J		0.08	0.08	0.08	0.08	0.08	0.08
Gas composition	xCO(%)	26.74	24.60	23.15	21.44	20.01	18.46
	xH_2(%)	18.59	19.01	19.52	20.00	20.28	20.54
	xA(%)	0.15	0.07	0.08	0.04	0.08	0.08
	xCH_4(%)	0.36	0.46	0.58	0.69	0.81	0.99
	xCO_2(%)	4.62	5.81	6.99	7.94	8.91	9.82
	xH_2O(%)	2.25	2.86	3.52	4.21	4.91	5.62
	xN_2(%)	38.20	24.15	29.50	25.68	21.93	18.57
	xW_G(%)	9.09	13.04	16.66	20.00	23.07	25.92

Applying the energy balance equation with the definite losses through sensible heat allows determination of gas composition as a function of biomass moisture content and an assumed amount of burned carbon at reduction zone.

With the use of the homogeneous reaction can be seen the difference between the model prediction and real gas composition at lower gasification temperatures. At higher gasification temperatures, the predicted gas composition coincides with a real gas composition.

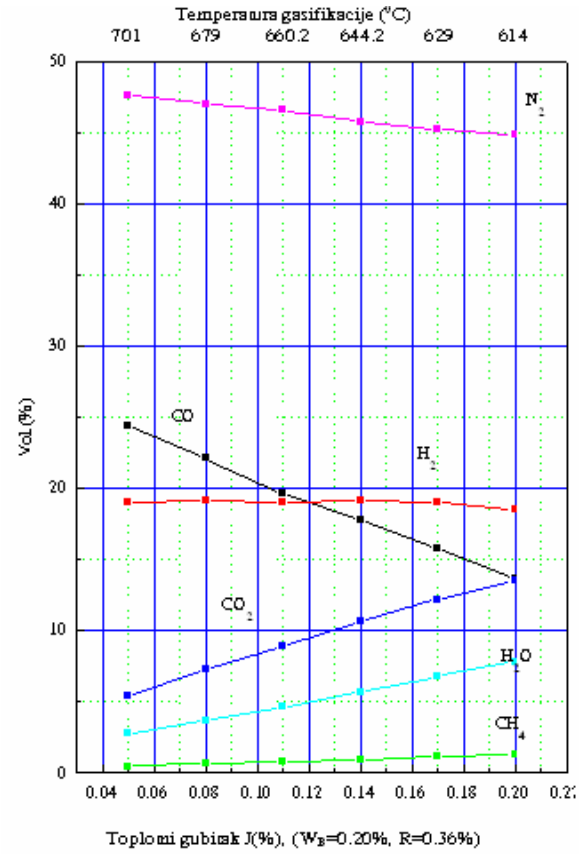

Figure 1.2 Gas compositions as a function of biomass moisture content

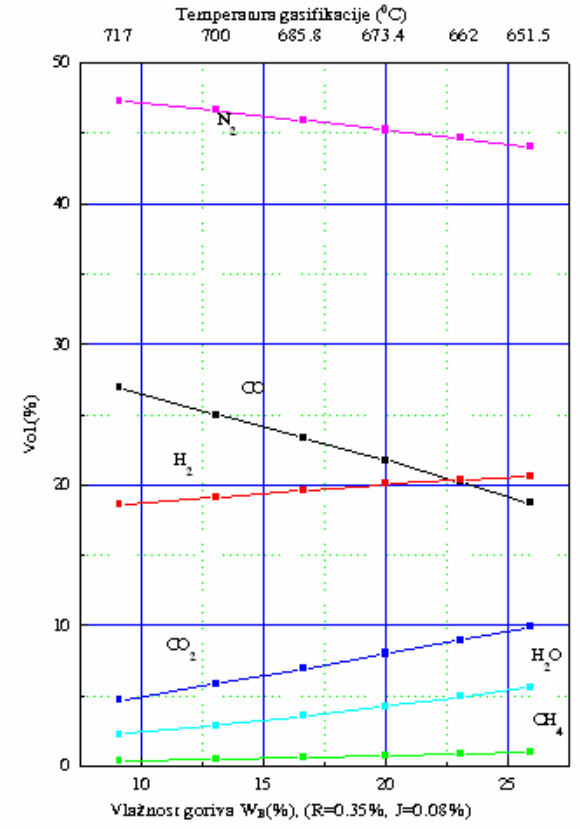

Figure 1.3 Gas compositions as a function of biomass moisture content

TABLE 1.3 GAS COMPOSITION

Gasification temperature (^{0}C)		624	614	604	594	584.2	574.2
The amount of injected moisture W_1(kg/kgB)		0.25	0.30	0.35	0.40	0.45	0.50
The amount of burned carbon R		0.29	0.29	0.29	0.29	0.29	0.29
Heat loss J		0.14	0.14	0.14	0.14	0.14	0.14
Gas composition	xCO(%)	15.70	13.90	12.40	11.0	10.00	8.81
	xH_2(%)	21.94	21.56	21.35	21.17	20.94	20.76
	xA(%)	0.49	0.14	0.11	0.24	0.06	0.09
	xCH_4(%)	1.40	1.72	1.94	2.13	2.48	2.81
	xCO_2(%)	13.08	14.10	14.61	15.44	16.16	16.88
	xH_2O(%)	7.90	9.30	10.0	11.10	12.14	13.22
	xN_2(%)	19.49	15.58	13.67	10.35	7.19	4.10
	xW_G(%)	20.00	23.70	25.92	28.57	31.03	33.33

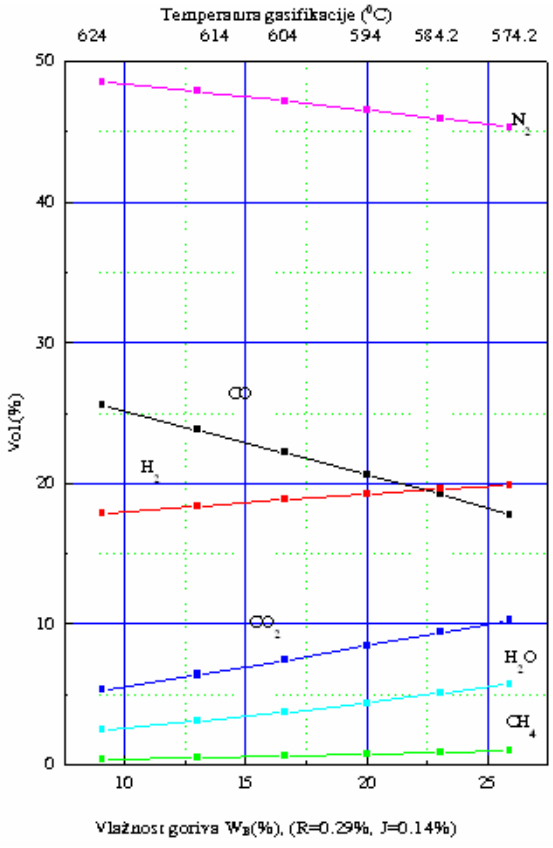

Figure 1.4 Gas compositions as a function of biomass moisture content

CONCLUSION

Comparing the model and experimental results of biomass gasification gas composition one can notice the same tendencies of some components, and some differences at the different biomass moisture content and the different amount of available carbon for endothermic reactions occurring. In a real gasification reactor the reactions equilibrium does not exist and it is the reason why the difference between model prediction and experimental results occurs. The values for equilibrium constants which are used for analytical determination of the gas composition, were obtained in laboratory measuring where chemical equilibrium does exist (homogeneous temperature, pressure and concentration fields after sufficient reaction time) that is, the condition which does not occur in a real process.
Comparing experimental results with the model prediction of the gas composition can be concluded that the model can be used for determination of the temperature and the gas composition of biomass gasification.

LITERATURE

1. KARAMARKOVIĆ, V., KARIĆ, M.: The model for determination of the gasification products temperature field in the reduction zone, Procesna tehnika, number 2-3, October 1998. Year 14, pages 255-258.

2. KARAMARKOVIĆ, V.: *The Comparative Analysis of Burning Wood Wastes and Gaseous Fuel From Wood Wastes*, International symposium on ENERGY & TECHNOLOGY TODAY AND TOMORROW, October 3-6, 1988., Zagreb.

3. WEYERHAUSER, Inc., *New Bern Biomass to Energy Project, Phase 1 Feasibility Study*, National Renewable Energy Laboratory, Golden, CO: June 1995. Report NREL/TP-421-7942

4. KARAMARKOVIĆ, V.: Energy loss due to irreversibility during combustion of solid and gas fuels, Procesna tehnika br. 3, pages 19-23, Beograd 1988.

5. MILES, T.R., et al., *Alkali Deposits Found in Biomass Power Plants. A Preliminary Investigation of Their Extent and Nature*, National Renewable Energy Laboratory, Golden, CO: February 1996. Report NREL/TP-433-8142

6. KARAMARKOVIĆ, V.: *Biomass combustion and gasification,* Faculty of mechanical engineering in Kraljevo, Kraljevo 2003.

INCREASE OF ENERGETIC EFFICIENCY AT CENTRIFUGAL PUMP

Dr Zoran Petrovic[1], Branko Radicevic[2], Miso Bjelic[3]

Summary: *In this papers it were showed how to determinate coefficient of specific power consumption for different types of regulation. It is also showed that using frequency regulation can be achieve biggest energy saving (11.5%), and at some specific areas of network pressure and flow rate, bypass system can be most effective. De-emphasis regulation system is always system of pure energy loss. Energy saving level can be higher if frequency regulator works at area of economic and stable pump operating considering well richness.*

Key word: *regulation, frequency regulator, bypass, de-emphasis, pump regulation graphic*

1. BRIEFLY REPORT

Increasing of the energetic efficiency is very important at all areas of industry. Optimization of the city's water supply systems takes important place at energetic efficiency area because there is a lot of space for decreasing of energy consumption which is one of the most important resources. From aspect of energy consumption and use of control system in water supply of our cities, we use technology from 1980.

Experimental results from this paper are connected to one of the Kraljevo pump stations. At the structure of the water production costs, electric energy has most important place. In theory there are a lot of solutions for control of asynchronous motors, but they were very expensive. Today's level of production technologies makes possible production of equipment for frequency regulations at low price.
In this paper is shown how specific consumption parameters can be calculated for different types of regulation. It is also shown that use of frequency regulator produce the biggest energetic savings (11.5%), and at some specific levels of pressure and flow rate, bypass system can be the most efficient. De-emphasis regulation system is always system of pure energy loss. Percent of energy saving can be higher if frequency regulator does regulation of revolution number at area of economic and stabile pump operating and if the pump operating is optimized with respect of well richness. Area of economic pump operating can be up to 80-90% relatively to pump efficiency at the nominal duty. Using the suggested methods, energetic efficiency energy consumption for one pump station for different types of pressure regulation.

3.SPECIFIC CONSUMTION OF ENERGY

Considering percent participation of individual flow rate vs. maximal flow rate during the total number of working hours for some relevant period of time and using the coefficient of specific consumption of energy (fig 1.b) for system with applied frequency regulator, efficiency percent can be calculated for any flow rate.
In case of de-emphasis systems, specific consumption of energy is always at maximum flow rate. If we use smaller flow rate, specific consumption is increasing, can be raised up to 15%. At the basis of research, when it is economic reasons in question, investment in frequency regulation equipment is very reasonable.

2. INTRODUCTION

Water consumption at production and distribution systems fluctuates significantly during the 24 hours. It is very small by night, but during the day is much significant.

Wells can be sorted in two different types. First type is corresponding to those who have one well from which water is directly pumped to water supply network. Second type of wells corresponds to those who have system of wells and from where is water pumped to storage tank.

Subject of this analysis is selection of type of regulation for motors control at pump stations with tendency to improve energetic efficiency.

Centrifugal pumps and related equipment are two systems with serial link. Regulation of flow rate can be achieved at one of two next ways:

- using de-emphasis equipment
- using bypass control
- control the pump speed rotation

Upon the choose of new systems for motors control, it should attend to possibilities of using them at extreme conditions. At first part of this paper it is shown specific

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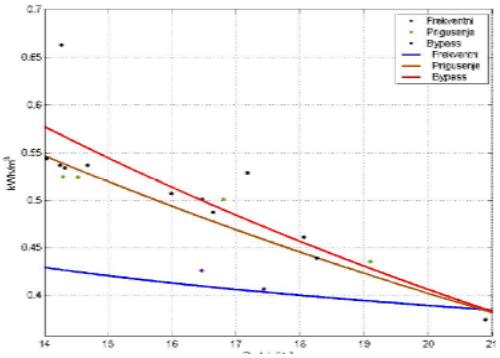
rapidly. In case of systems with speed regulation, specific consumption of energy is not only decreasing with decrease of flow rate, but also gain minimal work point and works at maximal percent of efficiency.



a) Energy consumption vs flow rate

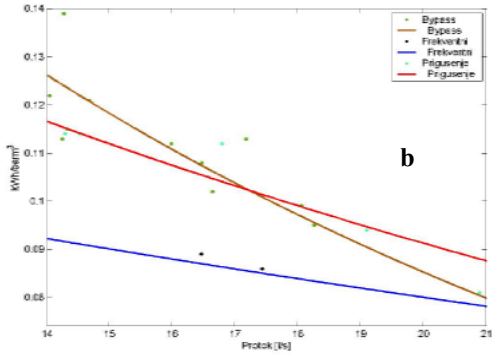


Fig.1. b) Coefficients of specific consumption of energy vs. flow rate

4. ENERGETIC EFFICIENCY

In matter of work time consideration for de-emphasis work regime, it is necessary to observe flow rate, pressure, number of working motors for a long period of time. If we add product of relative flow rate quotient comparing to maximal flow rate to product of relative quotient for specific consumption of energy, we will get a cumulative percent of system efficiency for system with applied frequency regulator vs. de-emphasis system.

Table 1. Cumulative efficiency coefficient for de-emphasis and frequency regulation systems

Flow rate [l/s]	Q/Qmax [%]	Relative quotation[%]	Percent of participation [%]
21	32	100	32
19	45	86.3	38.84
17	9	83.5	7.51
15	1	80.4	0.80
13	5	76	3.8
11	8	73	4.38
< 11	2	60	1.2
		∑	**88.53**

5. REGULATION DIAGRAM

Affirmation coefficient of specific consumption of energy is the best way for determination of best system for flow rate regulation at centrifugal pumps.

The most economic way for flow rate regulation is regulation by changing the number of revolution of pump, with limitation that pump must work at defined regulation area.

5.1 Pump characteristics at different number of revolutions. Regulation diagram

If we use following marks: Q for flow rate, H for effort and η for efficiency, then the work characteristics are functions of flow rate H(Q), N(Q) and η(Q) calculated at constant number of revolutions (fig. 2.)

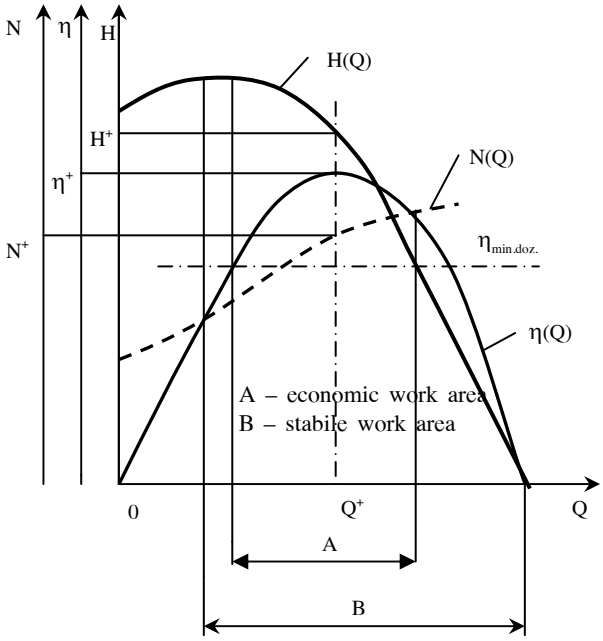


Fig. 2.

The most efficient regime of pump functioning is called nominal work regime, and parameters at this regime are shown at fig. 2. like Q^+, H^+, N^+, and $\eta^+=\eta_{max}$. Area of economic pump functioning is restricted by smallest acceptable efficiency percent. This area is usually restricted with following restriction, $\eta \geq (0.8\text{-}0.9)\eta^+$, where bigger value corresponds to bigger pump. Area of stabile regimes is at monotonously decreasing part of H(Q) characteristic ($dH/dQ<0$).

Left flow rate at economic work area for centrifugal pump is usually bigger than flow rate at stabile work area border, so the regulation area is economic work area.

If we use following marks: $Q(n_0)$ and $Q(n)$ for flow rates at revolution numbers n and n_0 and $H(Q(n))$, $N(Q(n))$, $\eta(Q(n))$ for work characteristics at $n \neq n_0$ then from analogy theory for flow in turbo-machinery follow:

$$\frac{Q(n)}{Q(n_0)} = \frac{n}{n_0}, \frac{H(Q(n))}{H(Q(n_0))} = \left(\frac{n}{n_0}\right)^2, \quad \frac{N(Q(n))}{N(Q(n_0))} = \left(\frac{n}{n_0}\right)^3, \eta(Q(n)) = \eta(Q(n_0)) \qquad (1)$$

Automodel flow at Reynolds number are called flows which has coefficients of flow resistance that not depend of Re. Flows that can be called automodel has following characteristics: Re·u = $5 \cdot 10^5$, Re·u = uD/ν, where D is diameter of pump's rotor, u-circumference speed, ν - coefficient of kinematical viscosity.

Equation (1) can be used at following condition:

$$n \geq \frac{3 \cdot 10^7 \cdot \nu}{D^2 \pi} \left[o / \min\right] \quad (2)$$

Where for clean water at 20°C, $\nu = 10^{-6}$ m^2/s

Work characteristics are affirmed at n_0, using equations (1) and (2) and can be copied for other number of revolutions (fig. 3.)

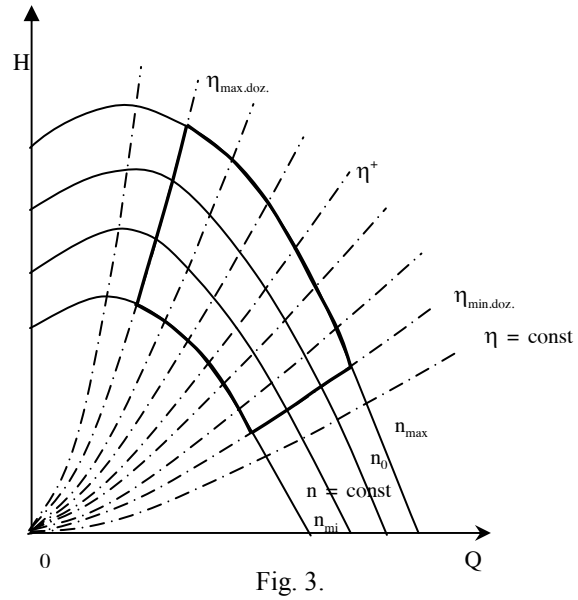


Fig. 3.

If we eliminate n/n_0 from (1), we will get:

$$H(Q(n)) = k_p (Q(n))^2 \text{ , for } \eta = \text{const.} \quad (3)$$

$$k_p = \frac{H(Q(n_0))}{(Q(n_0))^2}$$

Conclusion is that similar work regimes lie at parabola (3) apropos these are parabolas of constant efficiency percents (fig. 3.)
At stabile work area, characteristic $H(Q(n_0))$ can be interpolated by following polinom:

$$H(Q(n_0)) = a_0 - b_0 Q(n) - c_0 Q(n)^2 \quad (4)$$

Coefficients a_0, b_0, c_0 can be determinate using the least square method. Using this method, error value is smaller than 1%.
With respect to (1) and (4), characteristic H(Q) at different revolution number can be interpolated by following function:

$$H(Q) = a_0 \left(\frac{n}{n_0}\right)^2 - b_0 \left(\frac{n}{n_0}\right) Q - c_0 Q^2 \quad (5)$$

The biggest number of revolutions at which pump can work is restricted with respect to strength of work elements.
At water supply systems pumps are driven by low power electro motors, so modern regulations of these pumps can be done using frequency regulation. Frequency regulation can not just decrease but also increase number of revolutions. Number of revolutions can't be increased more than 20% beyond nominal number. The smallest number is defined by (2). At lower numbers of revolution, efficiency is decreasing.

With respect to smallest and the biggest number (n_{min}, n_{max}), the smallest allowable efficiency and restriction that pump can't be in unstable area at diagram (3) we can isolate regulation diagram (bordered area at fig. 3)

6. CONCLUSION

Increasing of energetic efficiency for centrifugal pumps at water supply systems is very important because it can be saved up to 11.5-20% of electric energy which has the most significant part at drinking water price. Except that, electric energy is one of the most important resources, so its rational use can achieve multiple benefits. Economic reasons for investing in frequency regulation an equipment for work optimizations are obvious.

7. LITERATURE

1. Petrovic Z., Radicevic B., Bjelic M., *Increase of pump power efficiency at the water piping system in Kraljevo,* Industrial Energetics 2004, Donji Milanovac.
2. Petrovic Z., and others, Research project no.42b-elaborat, *Optimization of pump systems for cities water supply,* Faculty of Mechanical Engineering in Kraljevo, 2004.
3. Bogdanovic B., Spasic Z., Bogdanovic-Jovanovic J., *Possibilities of pump work regime regulation using revolution number change with respect to restricted area of its stabile and economic functioning*, Conference of yugoslav society for hydraulic research, Soko Banja, 2002.
4. Bogdanovic B., Nikodijevic D., Vulic A., *Hydraulic and hydromechanic power transmiters*, Faculty of mechanical Engineering in Nis, 1998.

ENVIRONMENT PROTECTION AND CHEMICAL ACCIDENTS

Rade Biocanin.[1]

Abstract

Not a long time ago we were the witnesses of a number of accidents that included dangerous chemical substances during the transport. This fact is also important because we are the crossroad of numerous important European communications where a lot of such transports are passing by. Great number of such substances can seriously damage human environment for a very long period of time. The risk is defined as a product of a failure probability and its consequences. This work studies such events according to different parameters, trying to show the way how to successfully prevent them and protect from this threat as in the peace time, such as during the war operations.

At the time when dangerous substances are transported we usually don't have the valuable information about everything we need to know to prevent it. The emphasis of the paper is on chemical risks caused by structural failures leading to the serious involving pressure wave, flames, explosions and toxic contamination. So, realization of the universal and united system of NBCD gives us a possibility, using modern communication equipment and very effective mobile units, to react in a real time and successfully perform monitoring, alarming, protection and decontamination.

***Keywords**: human environment, risk, chemical accident, dangerous substances, transport, contamination, risk management, monitoring, protection, preventive measures, decontamination, mobile system*

1. INTRODUCTION

Chemical accidents are damages of production plants or damages that appear with toxic, flammable or explosive substances. Impacts happen suddenly and without control, so most of the liquid, evaporation or aerosols release in long term of time. Contamination of objects, atmosphere, and soil occurs with consequences for humans and nature.

Uses of chemical weapons in war, chemical accidents in peace and terrorism have similar characteristics of effects and consequences on the nature. Differences reflect in diversity of chemical compounds, their amount, dangerous concentrations, big range of effect, difficult identification etc. By analyzing past events of chemical accidents we can say that they were divers with heavy consequences on human population. Chemical accidents mostly happen in facilities of production, but they also happen in car accidents (distribution of dangerous chemical cargo). In the case of heavy accidents many hours and days had past before population received warning about potential danger. Reactions of accident in a country appeared with delay so the consequences were higher.

Many facilities have great amounts of toxic substances which are raw materials or final products intended for peace or war purposes. Causes of chemical accidents lie in fire (40% of accidents), explosions, and uncontrolled turbulence of toxic material in atmosphere, water and soil. They occur because of old technology, "higher force", negligence, disrespecting proper form of protection, diversion, sabotage, terrorist actions etc.

In war in conditions of chemical weapons usage, terrorism and conventional weapons, number of chemical accidents with enormous consequences would be great. A problem is present in the case of chemical accidents, that they are discovered much too late or never and that the cause of accident is never discovered, many of them happen during the night and in series. Chemical accidents can happen in multiple ways, explosions, terrorist actions, war impacts, old technology, disrespecting proper form of protection etc. By that, vast amount of toxic material goes to atmosphere and in the soil and it can be very dangerous to plats and human population. As chemical facilities are often located in urban surroundings, accidents present great danger to human and nature. There are many significant industrial objects in Balkan, with various technologies, complicated warehouses and difficult transport. Transport of harmful and dangerous material goes through air, by see or river, by railroads and highways, through pipelines and other sorts of transport. That is very much alike human blood veins and it can be easily compared. Harmful effects of these accidents are mostly of local character but they can be even regional or international.

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Picture 1. Consequences of chemical accidents are catastrophic

2. CHARACTERISTICS OF CHEMICAL ACCIDENTS

Damages in stationery objects are all damages in production facilities, storage rooms and pipelines in production system. Basic characteristic is that every possible location of damage is known. The problem is that we do not know in advance when damage will occur. Next characteristic is also familiar, all kind of chemical substances that can leak out are known. They are being determent by the sort of technology. Only if they change, which does not happen very quickly, the number and sort of dangerous chemical substances will change. Taken this into consideration we must take care of amounts of substances, because they change during production, which depends on dynamics of supply, production holdbacks and other. However, from the point of environment protection, that is, necessary measures for damage sanitations it must be taken into consideration the number of chemical compounds that are being used so as the amount that is being stored in a facility. Only then safety measures can be predicted to eliminate consequences.

When we speak about sorts of chemical substances, and their amounts, we should emphasize that there are more than just those that go through chemical process, but also the substances that appear as side products or inter products in production process and that they can in a case of damage be relished into the surroundings. Chemical accidents represent suddenly and uncontrolled release of dangerous and harmful material into the surroundings. Fire, explosions, high pressures and burst of contaminators cause great material damage, victims, destructions and degradation of nature for a long period of time with enormous consequences. Damages in non stationary objects are those that happen during the chemical transport by water (ships) or ground (railroads and automobiles) transport. By this we will leave out air transport because this transport is unique.

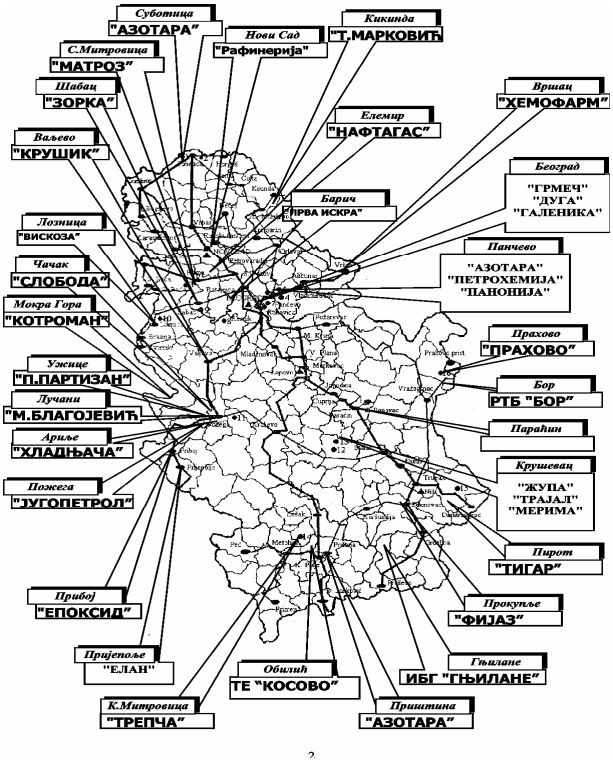
In case of industry accident, there would be an occurrence of explosion or so called strike of fire ball, fire and uncontrolled appearance of contamination, which would lead to sudden appearance of toxic clouds, evaporations and aerosols. By keeping that in mind, accident in a chemical facility could be classified in four levels of danger:

I Level (local): effects would be limited only to facility, warehouse, and industry in which the accident would happen. For its control and sanitation would only be required local means and forces.

II Level (city): effects would affect a wider territory and it would require forces and means of the city to control and sanitize the accident.

III Level (regional): this means an accident in a big territory whose effects are of regional significance. Control and sanitation would require joint local and regional forces.

IV Level (interregional): accident is of interregional proportion. For control and sanitation are required special mean and international aids.



Picture 2. Possible contaminators in cities in Serbia

Summing all information about damages followed by chemical leaking into the nature, we can say that we are confronting with momentarily and consequential effects which are practically the same as the use of chemical bio weapons. In the case of Mississauga there was the chlorine- the first bio poison used in World War I.

Table 1Locations of chemical accidents

Location of accident	Fixed installation	Sort of transport	Other locations

No. (%) accidents	379 (53)	246 (34)	97 (13)
Scope of accident	Technological catastrophe	Major accidents	Important accidents
Substances	Gas (propane, butane, LPG, propylene, butadiene, …) Mine-explosive resources (explosive, dynamite, ammo, pyrotechnical resources) Oil derivatives (oil, benzyl, kerosene, oils.) High-toxically substances (chlorine, ammonium, phosgene) Pesticides, acids, base and other.		
Remark: *In this table are not being taken into consideration the values taken during an air bombing of chemical facilities by NATO aggression on Iraq, Libya, ex republics SFRJ, SRJ and other. Evaluation is still in progress.*			

Seriousness of this problem illustrates the knowledge which was gained by recording the situation in Nis in scope of production facilities. Among the other, some of conclusions were brought:

Most of the facilities had not developed systems of work and assignments of proper employed personnel in the case of an accident.

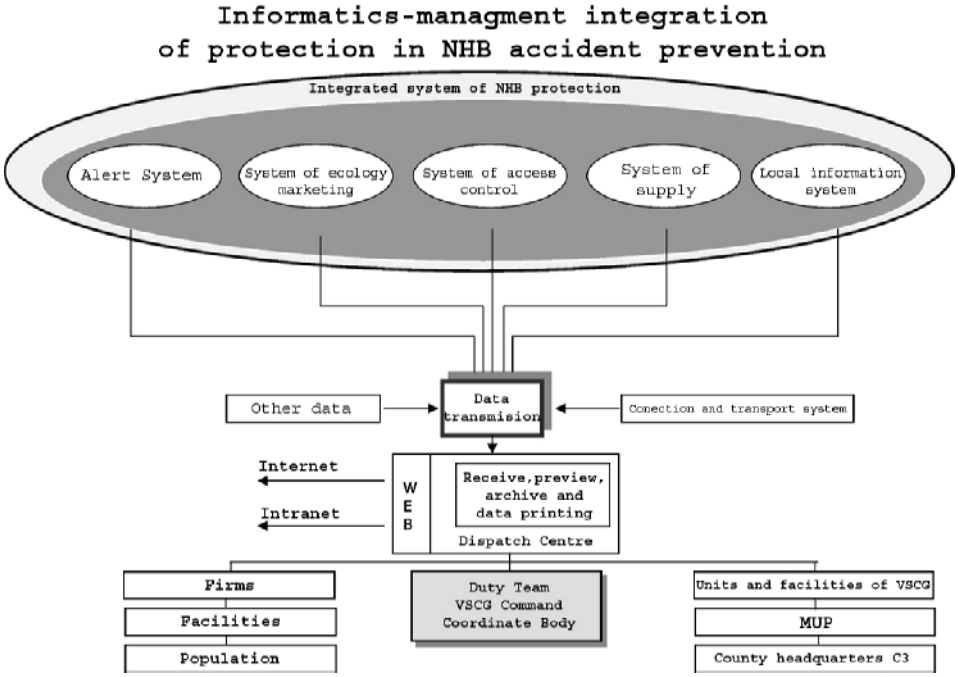
- That there had not been done a cadastre of dangerous material, and that some of the facilities do not have records about dangerous material;
- *That the state of alert in the case of an accident is not on required level;*
- That the training of employed personnel is being performed only for cases of explosions and fire, not in the case of chemical accidents.

Picture 3. Chemical accident in a facility

3. MANAGEMENT OF PROTECTION QUALITY

By perceiving all of this elements of potential chemical accident and their mutual influence we come to conclusion on which protection of population, units and facilities is being made. Security measures against NHB accident is monitored by the orders of commandant of the garrison (airport-seaport) in cooperation with MUP and persons responsible for local community. Orders for security measures have a cause of security, assignments, forces and means, warnings, alert, measures of chemical protection, ways of a region evacuation, forces and ways of engagement in security assignments, accidents control, removing the consequences, logistics organization of command and connections In order to effectively response to chemical accidents in these conditions it is necessary to define and form adequate forces for completing assignments for security measures - protection of environment. In the form of program assignments it is necessary to define a unique system of ABHO (constantly on duty and mobile), to prevent or lower consequences of chemical accidents, followed by leaking of chemical substances into the environment. In the form of AIS environment protection there should always be data (with what crew, work teams are specialized for high professional work with certain groups of chemical substances) for sanitation of accidents consequences and other damages. Solution should be found in form of improvement of present system of ABHO society, that is, he's subsystem PNHB security of military and civil defense and protection society. It is also needed the modernization of means and equipment, especially for conditions of security – protection from nuclear and chemical accidents in peace. It is necessary to train personnel, that can effectively respond to go there and chemical accident in peace. In this paper we're not discussing the causes of social, ideal, material or other aspects but we're facing the fact that in that cases the information as were late. Causes were different: human factor, technological factor, late discovery of danger, fear of consequences and responsibility, political reasons and other.

Discovery and following of distribution of contaminated cloud after the chemical accidents is possible to monitor with half empirical model. In this case, in the zone of accidents the primary cloud of contamination appears by steam release, gases and aerosol poison after which by the influence of whether is being distributed to certain distance. Larger dispersion systems first of all contaminate the ground and objects, and then evaporate and form secondary contamination.



Picture 4. Automated information system of NHB protection

Most chemical facilities, especially those with intent and production carry in self certain risk in the process of production and material distribution. Therefore it is necessary to constantly monitor and prevent, on scientific basis, chemical accidents. Most of the world countries can't great importance and insist on readiness in case of chemical accidents, and deceive to form international body for safety of modern technologies. In this way, it is required the responsibility of governments that do not take certain measures of protection on work and do not inform international community about danger, that can happen.

Plan of security of chemical accidents in these is being worked on the level of production, garrison (Airport, seaport) of military region and county. The barrier is the command of the garrison (Airport, seaport) and in realization of the work is also engaged:

- Coordination team for security from accidents in peace,
- Experts command and units in garrison,
- Proper authorized and expertise body of country management and facilities

By this plan is being enveloped all the essential interests for the organization of security activity with which are being made conditions for live and work of units (facilities) in the case of accident. Plan of security consists of danger evaluation from an accident, conclusion from estimation and orders for organization of security. With these documents there also other essential documents that provides better organization of security (men with the preview of element estimation, when of forces engagement, directions for teamwork, plan of connections and other).

Basics of the plan are being made by an evaluation of danger from the accident and the quality of information will depend on the quality of security and protection of the environment. The evaluation of an accident is a process in which is constantly monitored the condition and changes of threat in objects and settlements in the zone of responsibility and it consists on: evaluation of source of the danger from the accident, evaluation of threatened and units and objects, evaluation of territory, evaluation of whether and climatic conditions, forecast of primary and after stricken regions, evaluation of consequences of accidents and other

In the form of this estimation the number of production facilities and other objects are being defined, their position in correlation of vital objects and facilities and the type and amount of dangerous substances on disposal. Data about facilities and other objects which are occupied by production, processing, transport and other activities and in connection with dangerous materials are very important and they are the basics of other estimations. These data are received from the authorized county parliament and the data about the activities with dangerous materials from the code of processing. Data can be compared with the data from the, communal inspection, that is, inspector for protection of environment. The same time we get data about sort and amount of dangerous material. Based on the data, a list is being made of the production facilities that handle dangerous material by using the code book that defines the risk of accidents and planning of measure to eliminate consequences when the dangerous material is present in the amount equal or higher than listed in the "book of dangerous material after which a

cadastre of dangerous material is being made. All of unnamed material is defined by the code book.
It is important to say that the possession of chemical material does not present a potential source of danger. Therefore, who will be the potential source of danger and go into the cadastre of potential source is being decided according to sort and amount of material they possess. In the code book the procedure is defined when in one place are more of materials, that is, when one material has, at the same time, properties of more sorts of dangerous material.
For every material from the cadastre are being determent its properties. These data are relevant for the sort of means for protection, solution for decontamination, dimensions of the region's and other. The most significant data that must be known are: name of the material, manufacturer, and year of production, quality, and package. About physical properties we should know: state of aggregation under normal circumstances, color, scent, temperature of melting on twenty degrees, air density. Most important chemical properties are: molecule weight, empirical and structural formula, reaction capability (moister sensitivity, oxygen sensitivity, possibility of the decontamination, reaction with acids and bases and flammability and properties of decontamination).
Maximum of three amounts during the chemical accident is being estimated by the fact mother in:

- Ideal models, which suppose that the surface of horizontal cut of the container is constant, that the material is released from a hole in the wall, that it is not two phase system and the they're no resistance during the release
- Real models, which regards the phenomenon of friction
- Two phase models, which regards the quality and the specific volume of the mixture of evaporation and liquid
- Models that regards sudden burst of liquid, gas and steam

In this part of estimation data is being determent according to manual. Also, it is estimated the position of the potential source of danger if an accident might happen during the transport of dangerous material. By that the data is being established about the communications with which transports is being made, distance of communications between objects, azimuth, sectors in which the possibility of an accident is greatest, relative difference of height, natural and artificial obstacle between source of the danger and threatened objects. On the basis of all these data the cadastre of potential source of danger is made.
And the map (codebook predicts proportion of 1:500 to 1:10000) the source of danger is being marked: industrial objects, warehouses, transport and means on communications. On the map is also being marked the izo-lines of specific concentrations of gases, aerosols and solid particles of dangerous material (in g/m^3 or mg/m^3) for concentrations that cause death for momentarily death, that are dangerous for people unless immediate evacuation is performed, that can be harmful to shield of people if exposure last more than 30-40 minutes, which are determent as MDK and concentrations that are taken as the top value of a emission. By calculating the range and concentrations, the most negative weather conditions are being taken, obstacles between source of danger and threatened objects, the most possible wind direction, objects that channel movement of the clouds with dangerous material (streets, heights, valley's and other). Besides that, on the map is being marked the limitation of the zone and objects that are threatened, then units of civil protection, department for observing and information and other)
In the table are written the data about the source of the danger: name of the facility, type and amount of dangerous material, probable cause of accidents, maximum of the least amount on accident, procedure and material for neutralization, distance in miles from the source of the danger, and many more time available for unit alert and bad conditions. By estimation of endangered object from possible accidents in the zone of responsibility the degree of danger, that is, the possibility of influence of accident on objects and settlement is being perceived. Evaluation is done by the usual methods as for other situations. The condition of objects and the quality of means and equipment for detection and identification is determent, for chemical protection and for removing the consequences. So, the endangered units or object can be from irrelevant to very high threatened.
It is important to say that it can be influenced to lower the danger. Endangered units or object are estimated on the basis of the probability of accident and the possible consequences, by which it is determent in the risk is acceptable. Acceptable risk that can be managed under certain circumstances is foreseen by regulations and activities. If the risk cannot be managed under certain circumstances it cannot be accepted. The risk quantifies as minor (I), little (II), medium (III), large (IV) and very large (V). Risk qualifies on the basis of accidents and possible consequences.
By estimating the territory we perceive all of her elements, which influence the appearance of the accident, spread and behavior of chemical effects, engagement of capacity of territory through solving problem of control protection and elimination of consequences. In addition to that, we estimate the micrographic and urbanity characteristics: settlement and surroundings, relief map, cover, communications, and the especially natural and artificial obstacles between sources of danger and objects. After that, it is estimated at the possibility of evacuation, as the directions for evacuation. In form of evaluation is considered beta of possibility of the military garrison, production facility, civil protection, department for observing, and information about accidents (control of danger, announcement and information, organization of protection, and possibilities to eliminate consequences and neutralize the source of danger). Use of computers for monitoring the spread of contamination in atmosphere, time to response on the accident is

significantly lowered and this is of the great importance. Possible consequences of an accident are seeing separated the P3P and N3P, on the basis of the data about the source of the danger, condition of the units facilities and whether data. On the basis of seeing possibilities we come to conclusion about necessity of actions in control, protection and removing the consequences. By perceiving all these elements of estimation from the potential accident and influence we come to the conclusion on which is planned and performed the protection of the population and security of units and facilities from NHB accident periods security from accidents in these is being regulated by the orders of the garrison commandant (airport, seaport) and by the orders of the president of the county.

Picture 5. High capability during the rescue

4. CONCLUSION

Big risks in production, transport, archiving and use of dangerous and harmful substances to life and health of people, animals and plants lies in possibilities of chemical accidents in peace, direct war danger. Analyzing previous chemical accidents in the world and here we can say that there were many, mostly by surprise, with hard consequences for human, animal and plant world.

Defense system should unite all parts of the present forces, means and objects, in the form of one unique system ABHO (PNHB military security, office for observance and information, civil defense and protection). Important place and roll here have offices: traffic police, fire office, ambulance, office of facilities and other period's special role and place have units and facility of ABHO, VMA, VTI, institute for nuclear science "Vinca", SANU, high education and scientific facilities, offices for health protection, offices for preventive medicine, laboratories of facilities and other. In the system should be included specialize teams of chemical industry facilities. Basic part of the system should be office for observance and information which can manipulate with all data about substances that are being transported, their destination and other relevant data.

For an effective answer to accident in peace, in current conditions, it is necessary in form of organization-formation changes and further enlargement to the find and form adequate forces for completing the special assignments in the form of security in these and defense in war conditions. It is necessary, also, modernization of means and equipment and training the personnel, which will be in the condition will effectively respond to accident in peace. It is necessary to have a unique response unit, highly trained and prepared for eliminating the consequences of an accident in peace, informed of environment protection on the territory of our country. Planned activities of society from accidents in peace (prediction, organization, conduction and control of life security measures) are real and only way to prevent, control, protect and effectively eliminate consequences in all conditions.

5. REFERENCES

1. Uputstvo za obezbeđenje od nuklearnih i hemijskih udesa u miru, GŠVJ, Beograd, 1988.
2. *Biocanin R. Mere i sadržaji obezbeđenja od NiH udesa u miru, Bilten ABHO, ŠC ABHO, Kruševac, 1995.*
3. *Jakšišić S., Biocanin R. Obezbeđenje od hemijskih udesa u miru, Novi glasnik br. 3-4, VIZ, Beograd, 1996.*
4. *Marković D. i gr. autora: Osnovni procesi i stanje u životnoj sredini, Univerzitet u Beogradu, 1997.*
5. *Biocanin R.* Protection of the human enviroment in case chemical accident*, II regional Simposium* "CHEMISTRY AND THE ENVIRONMENT" 18-22.june 2003. Krusevac.
6. *Amidžić B., Biocanin R. Ekološki menadžment u funkciji zaštite i unapređenja životne sredine,* IV *Medjunarodna konferencija " SумOrg 2004", 06-10. 06. 2004.Zlatibor.*
7. *I. Burton,* "What happened at Mississaga"*, Planning emergency responce system for chemical accidents, Adminitrative Guidelines, World Health Organization, Regional office for Europe, Copenhagen, 1981.*
8. *Bogdanović M. Opasnosti od hemijskih akcidenata u Nišu i postupci za zaštitu životne sredine, FZNR Univerziteta Niš, 1998.*
9. Bela knjiga državne zajednice Srbije i Crne Gore, NIC *"VOJSKA", Beograd, 2005.*
10. *Vitorović S., Milošević M. Osnovi toksikologije*, Vizartis, Beograd*, 2002.*

OIL DEBRIS MONITORING AS A DIAGNOSTIC METHOD FOR FAILURES DETECTION AT AIRCRAFT ENGINES

Prof.dr Dragoljub Vujić [1]

Abstract. *Oil debris monitoring and its application for failures detection at aircraft engines are considered. Some practical experiences gained during realization of the monitoring system on the engine of military combat aircraft are exposed. A special attention is dedicated to definition a logic for failure detection.*

Key words: *aircraft engines, condition based-maintenance, magnetic detector, monitoring system, sophisticated dianostic systems, fault detection*

1. INTRODUCTION

At the beginning of the 1980s significant changes occurred in turbojet engines maintenance, in combat aircraft as well as in engines of civil aircraft of commercial flights. Instead of maintenance based to precisely defined number of flight hours [1] a new maintenance concept based on-condition appeared. This concept was first applied to the RB199 engine of the *Tornado* aircraft [2], which has been in use since August 1986. It was a very serious design, development and production project. This engine was a product of three leading European aircraft engines producers: English *Rolls-Royce*, German *Motoren-und-Turbinen-Union* and Italian *Fiat Aviazione.*

In the 1980s, *Rolls-Royce* and *Turbomeca* developed the *Adour* RT172-56 engine for the *Hawk* aircraft and the version RT172-58 with afterburning for the *Jaguar* aircraft. The engine is of modular design, equipped with magnetic chip detectors for early detection of bearing and gears failures, as well as with equipment for vibration pickups. In the late of the 1980s *Rolls-Royce* and *Turbomeca* developed a family of RTM322 helicopter engines with the 1345 - 1943 kW power range with digital electronic control and on-condition maintenance.

The *Eurojet* EJ200 engine of European hunter which entered in use 1995 also belong to a new generation of turbojet engines. The engine is modular design, and it represents an example of on-condition maintenance with build-in equipment for testing and monitoring.

The emphasized addition of reliability and maintenanceability of engines, especially in the USA aviation, and a need that aircraft delivered from the base operates without failures, require sophisticated maintenance systems and expensive diagnostic equipment. Such systems have to provide reliable, consistent state diagnosis and to minimize requirements for maintenance personnel training. These requirements can be satisfied only by the diagnostic systems based knowledge, so-called *knowledge-based system.*

2. ENGINE HEALTH MONITORING ON THE BASIS OF OIL DEBRIS MONITORING

A traditional method of quantitative measurement and analysis of particles of the wearing parts contained within the lubricating oil is used for determining health conditions of aircraft engines. Based on the analysis of this particles, in terms of quantity, size, shape, colour and material can be concluded about the source and kind of the incipient failure. The main aim of this method is to detect failures before they produce secondary damages and become evident by means of other methods as measuring vibrations, high oil themperature, etc. *On-line* and *off-line* methods with different occuracy and effectiveness are used for failures detection.

The *off-line* technology based on testing in laboratory conditions comprises spectral, ferrographic, colorimetric analysis, etc. It is a conceptually simple procedure that provides relativly accurate results.

2.1 Spectrographic oil analysis

Spectrographic oil analysis is used for detecting any wear of rotating parts which can cause a failure. The analysis is based on the nature and concentration of particles, total operating time, operating time since last oil sampling (evolution of concentrations), oil type and brand, and oil consumption. The extraction of a sample of 60 cc of hot oil is performed as soon as possible after the engine shutdown (15 to 30 min at the latest). The analysis determines any excessive concentration of wear material (Table 1).

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Table 1. Materials contained in oil

Iron (Fe)	Most significant metals
Titanium (Ti)	
Copper (Cu)	
Aluminium (Al)	
Nickel (Ni)	Secondary identifiers of parts distress
Zinc (Zn)	
Chromium (Cr)	
Silver (Ag)	
Phosphorous (P)	
Silicon (Si)	Oil contamination indications
Magnesium (Mg)	

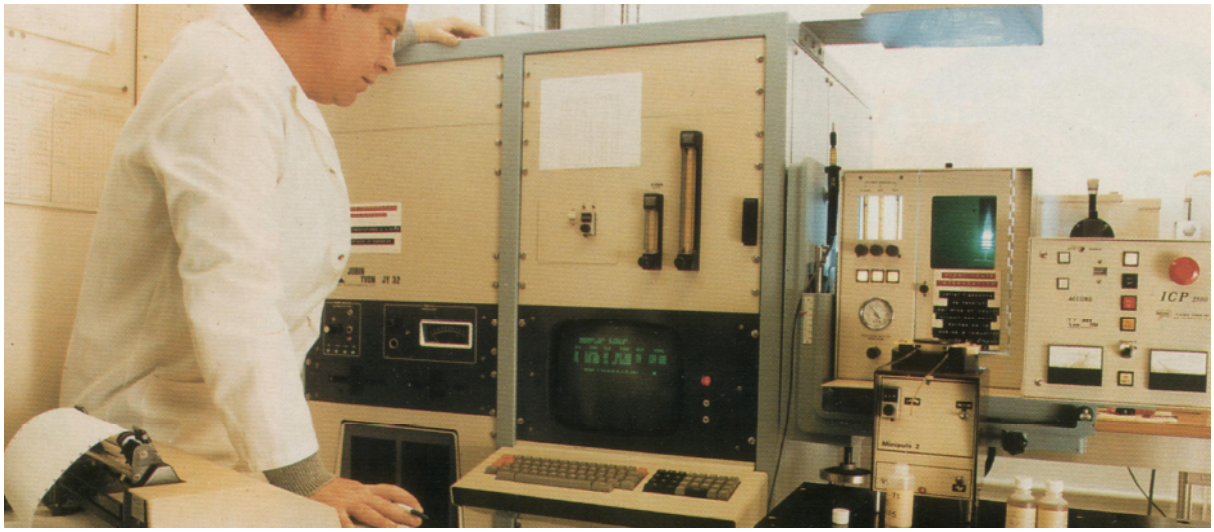

Fig. 1. Spectrographic oil analysis

However, laboratory analysises (Fig.1) require time and adequate equipment, and affect aircraft availability. Another major drawback is that there are no automatic rules for failure determing based on the analysis results and the conclusion has to be drawn from case to case. This means that the experience of operators plays a major role in the assessment. This approach requires a significant maintenance burden due to frequent inspections performed each of 10-20 engine running hours, as well as to the necessary time for analysis.
For this reason, great efforts have been made to develop a more requested monitoring system enable to automatically detect the beginning of a failure.

2.2 Monitoring system

Historically, the first „intelligent" system was the electrical chip detector, arisen as a result of the magnetic plug development. It consists of a collective magnet with two electrical contacts, acting as a switch. The switch is closed when the collected debris fill the gap between the contacts, thus providing an electrical indication about the amount of collected particles. Although this is a good method to avoid a scheduled inspection, the accuracy of the resulting information and related prognostic capabilities are questionable. The main question here is that gap size which should be specified in order to be capable of detecting the minimum particle that is deemed critical. Normal sizes are anyway in the order of 2 mm.
The electrical chip detector finds a major application in helicopter gearboxes, where the generation of a large amount of fine particles is not considered critical for engine operation, while occurrence of chucks has to be promptly detected. More sophisticated version of the electrical chip detector provide the capability to measure the resistance across the gap. This feature enables the monitoring of the debris accumulation and differentiating between critical and non-critical conditions.
Nevertheless, a systematic attempt to correlate between the resistance changes, debris type and quantity is quite difficult. A further refinement of the same approach is to quantify the size of the bridging particles from the energy required to destroy them. When the gap is closed, a series of the sparks is generated to try and open the gap. The energy required to destroy the particle is then related to the particle size. Although this system can detect debris in the micron range, the major drawback is the possible hazard related to the electrical discharge within hot oil. For that reason, it is necessary to provide an appropriate protection system.

Nowadays, a significant role in the failure detection belongs to closed monitoring systems providing mass indication of all particles accumulated on the magnetic sensor. Also, great efforts are made to define an appropriate logic that should be provided alarm for maintenance personnel whenever critical conditions for engine operation are detected. Therefore, it is necessary to define the rules related to particles generation. Number of particles, their mass and/or size and the rate of debris generation are the parameters used in this exercise. In the rule, more detailed and accurate measuring of the particles can be used to design of more complex and reliable detection system. From the review of the development and validation activity of the existing systems, it can be concluded that there is no common understanding about debris generation profile along failure progress as well as the exact relationship between the type of debris and the engine failure modes. In that sense, several interesting efforts have been done, but they still have not provided satisfactory results. Moreover, there is no general approach to the definition of system requirements, such as type of output and measurement accuracy and the approach to the validation task is not standardized. Although several interesting trials have been performed (laboratory investigations, rig tests, engine data collection) the definition of the criteria to assess correct system operation is left to the system supplier. For those reasons, the development of the specified devices above can not be considered to finish. There are still certain difficulties for the system designer to choose a technology for a particular engine application. The extensive flight testings are currently performed on engine of military combat aircraft.

2.3 Realization of the monitoring system

In the realization of the monitoring system it was assumed that all types of ferromagnetic particles, whatever their size, were significant to identify onset of a failure, and that the mass accumulation rate is the key parameter for engine health monitoring. Therefore, the first goal was to ensure that sufficiently high capture efficiency could be achieved by the collective device, in order to base the analysis on the greatest possible debris quantity. This was obtained by using the centrifugal separator within scavenge line.
A photo of the sensor tip, about 2 cm in diameter, completely covered by particles, following a gearbox breakdown is presented in Fig.2. The need to distinguish significant events, i.e. high debris generation rates, from environmental noise was the major problem during the system validation. Also, the difficulty arises from high temperatures which are experienced in the scavenge line.

Fig.2 Sensor for debris collection.

Although some technical difficulties, the major problem was the definition of a failure detection logic. In that sense, it was a question how to define a warning threshold. The problem was solved by means of a bearing dectruction test. Rig simulating the operating conditions of shaft bearing on the engine was used in the test. The bearing was damaged before the start of the test, in order to induce a failure. The monitoring system was fitted onto the scavenge line in order to collect the produced debris. The bearing failed after 105 hours testing. Fig.3 shows the results obtained from data processing. It can be easy concluded that the highest debris accumulation mass rate, as an upper warning limit, is plotied a few hours before the bearing breakdown. This electrical signal, similar to the warning raised by electrical chip detector was a trigger for the maintenance service.
The experience gained from the rig testing was very useful to define a validation method on the engine. It has also statemented that the system validation can be done over a long period of monitoring normal engine operation, data collection and analyses. The background for defining some guidelines for the monitoring system is obtained from laboratory testings. The guidelines will be checked during the engine development testing.
The traditional oil debris monitoring, via magnetic chip detector, is used in parallelly to this system in order to avoid undetected failures. The occurrence of engine failures, although undesirable, would help a lot in the validation process. When sufficient confidence in the automatic oil debris monitoring function will be achieved, then it will be possible to discard the traditional inspection techniques and rely on the oil debris monitoring function alone.
As mentioned, the goal of the presented debris monitoring approach is to provide a simple and reliable criterion to warn maintenance personnel about the arising of critical conditions for the engine operation. This will induce all required additional investigations and analysis which can be better performed off-line in laboratory environment.

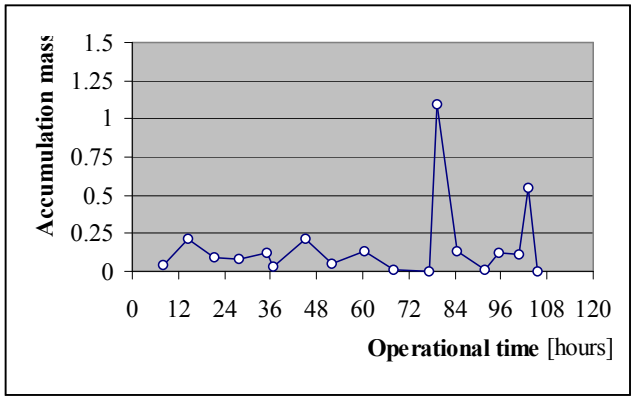

Fig.3 Mass accumulation

Due to relatively infrequent arising of failures detectable via debris generation, it should avoid false warnings and unnecessary maintenance actions. The maintenance personnel at the first line should only be informed whether the engine is safe to continue to operate or not. Of course, it is a great challenge when it is necessary from a relatively safe approach, based on regular checks, to across to the new on-condition warning system. Therefore, the reliability of the failure detection logic has to be well checked and proven through a series of back-to-back testings with the current methods.
Until that time the magnetic chip detector, despite all their limitations, will have an irreplaceable role on most in service engines.
Based on the previous considerations, it can say that a proposal for oil debris monitoring function, supporting engine on-condition maintenance, will be composed of: an automatic *on-line* device for quantitative measurement and indication of the amount of debris, an *on-line* failure detection logic, as well as of additional methods for *off-line* and *on-line* oil debris analyses.

CONCLUSION

The real time engine health monitoring and diagnostic systems enable to optimize maintenance procedures and to prevent fatal failures. Those systems can be significantly reduced engine life costs and whole aircraft costs. In that sense, the sensor technology for integration into engines of current and future aircraft develops rapidly. Great efforts are addressed to integral monitoring development that will be presented a future technology.
At oil debris monitoring systems, problems of the failure detection logic and warning threshold question of oil debris indicating to failure have not still solved. After ending flight testings that are currently ongoing and validation of the monitoring systems, useful on-condition maintenance tool will be obtained. Until then, the magnetic chip detectors, will have an irreplaceable role on most service engines.

REFERENCES

[1] VUJIĆ, D. Tehnička dijagnostika i njena primena u vazduhoplovstvu, *kumulativna naučnotehnička informacija*, br.12, Vojnotehnički institut, Beograd, 2003.
[2] Bergaglio L., Tortarolo F., RB199 Maintenance Recorder: an application of „on condition maintenance methods" to jet engines, Condition-based maintenance for highly engineered systems, Universita' degli Studi di Pisa, Pisa, Italy, September 25-27, 2000.
[3] BOLLER C., STASZEWSKI W., WORDEN K., Manson G., Tomlinson G., Structure Integrated Sensing and Related Signal Processing For Condition-Based Maintenance, Condition-based maintenance for highly engineered systems, Universita' degli Studi di Pisa, Pisa, Italy, September 25-27, 2000.
[4] VUJIĆ, D. Osnovni koncept sistema elektronskog upravljanja turbomlaznim motorima, Naučno-tehnički PREGLED, Vol.XLVIII, br. 5, 1998.
[5] VUJIĆ, D. Dijagnostički sistem turbomlaznog motora, *Tehnnička dijagnostika*, br.2, 2002.
[6] VUJIĆ, D. Dijagnostika stanja vazduhoplovnih motora na bazi monitoringa ulja za podmazivanje, *Tehnnička dijagnostika*, br.2, 2004.
[7] VUJIĆ, D. Turbojet engine maintenance systems, *Scientific Technical Review*, Vol.LIII, No.2, 2003.
[8] VUJIĆ, D. Sophisticated diagnostic systems in aircraft engines, *Scientific Technical Review*, Vol.LIII, No.4, 2003.
[8] VUJIĆ, D. Sistemi održavanja u vazduhoplovstvu, *Zbornik radova, XXVI majski skup održavalaca*, str. 17-28, Niška Banja, 28.-29. maja 2003.
[9] VUJIĆ, D. Sofisticirani dijagnostički sistemi i njihova primena kod vazduhoplovnih motora, *Zbornik radova, XXIX nuačno-stručni skup HIPNEF 2004*, Vrnjačka Banja, 18-21. maj 2004.
[10] AZZAM, H., ANDREW, M. A modular intelligent data administration approach for helicopter health and usage monitoring systems, *Proc. Insts Mech Engrs,* Vol. 209, ImechE 1995.
[11] CONTE, S., TORTAROLO, F. Oil Debris Monitoring as a technique for Engine Health Monitoring and Condition-Based Maintenance: the EJ200 experience, Condition-based maintenance for highly engineered systems, Universita' degli Studi di Pisa, Pisa, Italy, September 25-27, 2000.

COMPARATIVE ANALYSIS OF THE THERMAL EFFICIENCIES FOR THE USE OF DOWNDRAFT GASIFICATION PRODUCTS BY FUEL CELL AND GAS TURBINE

Rade Karamarković[1],Miljan Marašević[2]

Resume: Biomass as an alternative and environmental friendly energy resource will gain an important roll in total energy consumption of society. There are many different ways for the use of biomass. This paper examines the concept of using downdraft biomass gasification in conjunction with gas turbines or fuel cells to generate electricity. The syngas used in this paper is obtained from downdraft gasification of woody biomass.
Key words*: gasification, downdraft gasification, gas turbine, fuel cell*

INTRODUCTION

The use of biomass energy emits fewer amounts of pollutants than fossil fuel combustion. Green plants again use carbon dioxide produced by biomass combustion during photosynthesis reactions, while emissions of sulfur and nitrogen oxides can be ignored.
Biomass gasification represents the process of obtaining gas fuel by thermal disintegration of solid particles at high temperatures in the presence of medium for gasification. As a media for gasification can be used: air, water vapor, oxygen, carbon dioxide and hydrogen. The gas gained by gasification can be used for power generation, in industry, in metallurgy or for syngas production.

There are many different types of gasification reactors. However, commercially and technically the most important are: updraft (countercurrent), downdraft (co-current) and fluidized bed gasifiers. For the purpose of this paper, experiments on the half-industrial downdraft gasifier were generated.

In downdraft gasifier the combustion zone is in the upper part of the gasifier, while the produced gas leaves the reactor at the bottom (figure 1). For that reason, the products from devolatilization zone, which is located above the combustion zone (figure 1), must pass through the high temperature combustion zone, where degradation of tar and volatiles takes place. Another advantage of downdraft gasifiers is the possibility for use of biomass' moisture. That can substantially reduce the cost of the reactor usage.
For the reason of low organic contaminant loadings, downdraft gasifiers represent less danger for environment.

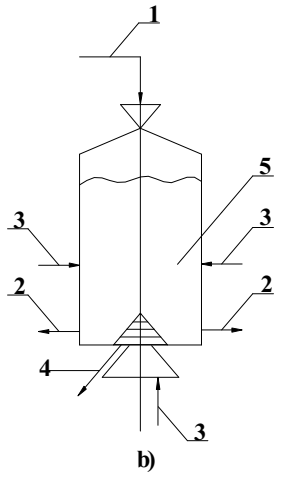

Figure 1 Biomass downdraft gasified

1- Biomass, 2-gas outlet, 3-gasification medium, 4-ash, 5-reaction zone

Downdraft gasifies have their own deficiencies. The reduction zone is placed near the gas outlet (figure 1) for that reason, the gas temperature at the outlet is very high concerning updraft and cross draft gasifies. This reduces the gasifier efficiency. However, with the development of fuel cells especially molten carbonate and solid oxide fuel cells the high outlet temperature of the gas is no more deficiency and intrudes coupling a downdraft gasification reactor with a fuel cell in a system for electricity generation. Downdraft gasification reactors also demand the adequate dimensions of biomass particles.
Downdraft gasifiers are relatively simple, low cost, low-pressure devices, which produce relatively clean gas suitable for power generation. Figure 2 is a schematic of a downdraft gasifier system, and Table 1 compares gasification technologies and gas contaminant levels.

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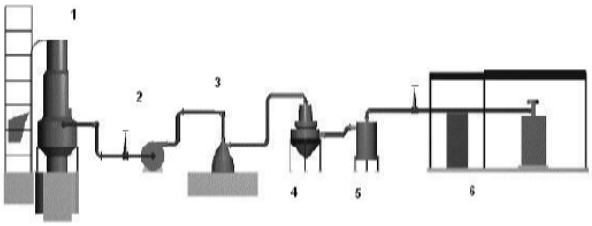

Figure 2 Downdraft gasification system
1- downdraft gasifier, 2 – blower, 3 – venturi scrubber, 4 - fine filter, 5 – check filter, 6 – power generator and room

Table 1 Gasifier contaminant loadings

Gasifier type	Tar production	Relative particulate loadings
Updraft	50000-200000ppm	intermediate
Downdraft	100-1000ppm	low
Fluidized bed	1000-50000ppm	high

In next sessions of this paper will be analyzed employment of the downdraft gasification process in systems with a gas turbine or a fuel cell for electrical generation.

All analyses were generated with the gas obtained from the downdraft woody biomass gasification. As the representative gas was taken a gas with the following volume composition: CO = 14.9 %, H_2= 15.3 %, CH_4= 1.6 %, CO_2= 10.5 %, O_2= 0.9 %, N_2= 46.3 %, H_2O = 10.5 %. This gas was obtained by the downdraft gasification of woody biomass with the lower heating value of 14283 kJ/kg. 1 kg of this biomass produced in half industrial downdraft gasifier 2.839 m^3 of the gas. This presents chemical coefficient of efficiency 81.6%.

THE USE OF GAS TURBINES FOR ELECTRICAL GENERATION

The efficiency of gas turbines for electrical generation is 30%-35%. The advantage of these turbines over fuel cells is that they can use the syngas with much lower purity. A downdraft gasification system is coupled to a turbine power system, which consists of the components shown in the Figure 3.

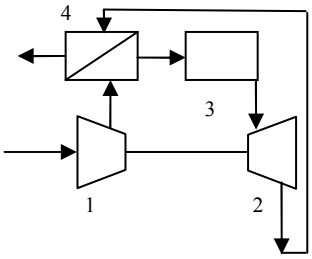

Figure 3. Generation of electricity by gas turbine
1 – compressor, 2 – turbine, 3 – combustion chamber, 4 – heat exchanger

If the average efficiency of a gas turbine is 33% from 1kg of woody biomass, with the lower heating value of 14283 kJ/kg, is obtained 3848 kJ of electrical energy or 1.07 kWh.

FUEL CELLS AND TYPES OF FUEL CELLS

A fuel cell is an electrochemical device that converts the chemical energy of a fuel directly into electrical energy by an oxidation reaction in which energy is liberated as electrical work rather than as a heat. Therefore, a fuel cell is not a heat engine and consequently is not subject to the severe efficiency limitation of the Carnot cycle. Fuel cell energy conversion efficiencies can approach 100% under the proper conditions.

Fuel cells are classified primarily by the kind of electrolyte they employ. This determines the kind of chemical reactions that take place in the cell, the kind of catalysts required, the temperature range in which the cell operates, the fuel required, and other factors.

Polymer electrolyte membrane (PEM) fuel cells deliver high power density and offer the advantages of low weight and volume, compared to other fuel cells. PEM fuel cells use a solid polymer as an electrolyte and porous carbon electrodes containing a platinum catalyst. They need only hydrogen, oxygen from the air, and water to operate and do not require corrosive fluids like some fuel cells. They are typically fueled with pure hydrogen supplied from storage tanks or onboard reformers.

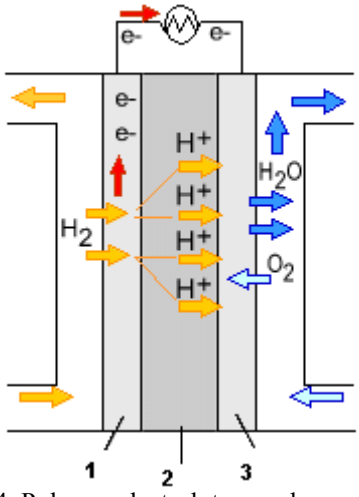

Figure 4. Polymer electrolyte membrane fuel cell
1- anode, 2 – electrolyte, 3 - cathode

Polymer electrolyte membrane fuel cells operate at relatively low temperatures, around 80^0C. Low temperature operations allows them to start quickly (less warm-up time) and results in less wear on system components, resulting in better durability. However, it requires that a noble-metal catalyst (typically platinum) be used to separate the hydrogen's electrons and protons, adding the cost. The platinum catalyst is also extremely sensitive to CO poisoning, making it

necessary to employ an additional reactor to reduce CO in the fuel gas. Therefore, these fuel cells are not suitable for use when as fuel is used the gas obtained from the process of downdraft gasification.

The most suitable fuel cells for the use of downdraft gasification gas are molten carbonate fuel cells and solid oxide fuel cells.

Molten carbonate fuel cells are high-temperature fuel cells that use an electrolyte composed of a molten carbonate salt mixture suspended in a porous, chemically inert ceramic lithium aluminum oxide ($LiAlO_2$) matrix. Since they operate at extremely high temperatures of 650^0C and above, non-precious metals can be used as catalyst at the anode and cathode, reducing costs.

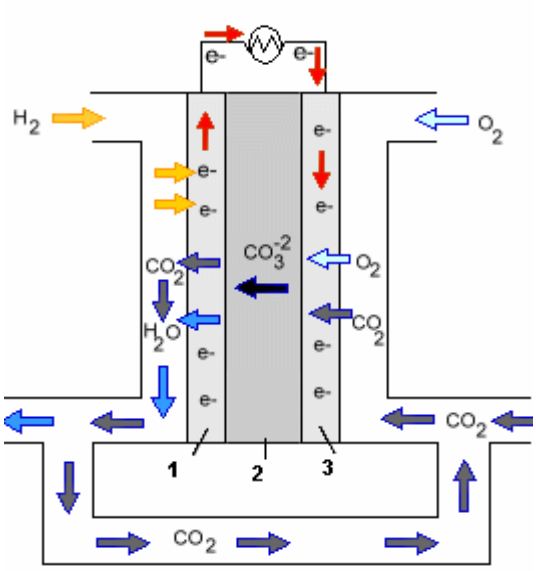

Figure 5 Molten carbonate fuel cell
1- anode, 2 – electrolyte, 3 – cathode

Molten carbonate fuel cells can reach efficiency approaching 60%, but when the waste heat is captured and used, overall fuel efficiencies can be as high as 85 percent. Molten carbonate fuel cells are not prone to carbon monoxide or carbon dioxide "poisoning" they can even use carbon oxides as fuel, making them more attractive for fueling with the gas made from gasification of biomass. They are more resistant to impurities than other types of fuel cells. The primer disadvantage of current molten carbonate fuel cells is durability.

Solid oxide fuel cells use hard, non-porous ceramic compound as the electrolyte. These fuel cells are expected to be around 50-60 percent efficient at converting fuel to electricity. In applications designed to capture and utilize the system's waste heat, overall fuel use efficiencies could top 80-85 percent.

Solid oxide fuel cells operate at very high temperatures around 1000^0C. High temperature operation removes the need for precious-metal catalyst, thereby reducing cost.

These fuel cells can tolerate several orders of magnitude more sulfur than other cell types. They can even use carbon monoxide as a fuel, which allows them to use gasification products as a fuel.

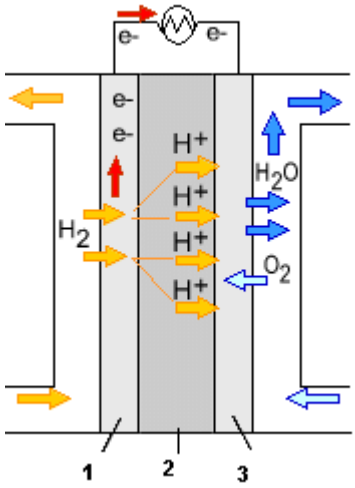

Figure 6 Solid oxide fuel cell
1 - anode, 2 – electrolyte, 3 – cathode

Table 2 delineates the different electrochemical reactions of PEM, MCFC and SOFC technologies.

Table 2 Electrode reactions for various fuel cells

Fuel cell	Anode reaction	Cathode reaction
PEM	$H_2 \rightarrow 2H^+ + 2e^-$	$0.5O_2 + 2H^+ + 2e^- \rightarrow H_2O$
MCFC	$H_2 + CO_3^{2-} \rightarrow H_2O + CO_2 + 2e^-$ $CO + CO_3^{2-} \rightarrow 2CO_2 + 2e^-$	$0.5O_2 + CO_2 + 2e^- \rightarrow CO_3^{2-}$
SOFC	$H_2 + O^{2-} \rightarrow H_2O + 2e^-$ $CO + O^{2-} \rightarrow CO_2 + 2e^-$ $CH_4 + 4O^{2-} \rightarrow 2H_2O + CO_2 + 8e^-$	$0.5O_2 + 2e^- \rightarrow O^{2-}$

ANALYTICAL AND REAL OVERALL COEFFICIENT OF EFFICIENCY FOR DOWNDRAFT GASIFIER-FUEL CELL SYSTEM

We can calculate the maximal coefficient of efficiency with the following formula:

$$(\eta_r)_{max} = \frac{\sum_P (n_i/n_{fuel})\bar{g}_i^{\bullet} - \sum_R (n_i/n_{fuel})\bar{g}_i^{\bullet} + \mathcal{R}T \ln\left[\prod_P (p_i/p^{\circ})^{(n_i/n_{fuel})} \Big/ \prod_R (p_i/p^{\circ})^{(n_i/n_{fuel})}\right]}{\sum_P (n_i/n_{fuel})\bar{h}_i - \sum_R (n_i/n_{fuel})\bar{h}_i}$$

Where:

g_i (kJ/kmol)– molar specific Gibbs functions at 25^0C and 0.1 Mpa

$\boldsymbol{R}$ = 8.314 kJ/kmolK universal gas constant

T (K)– the reaction temperature

P_i (Pa) – partial pressure of each gas component

P^0 = 0.1MPa

Since it is assumed that the reaction takes place at 0.1MPa and that all present gases are ideal gases that obey the Gibbs-Dalton ideal gas mixture low than partial

pressures can be expressed in terms of the mole fractions as: $(p_i/p^0) = x_i$, where x_i is the molar fraction of the component in the mixture.
Using the above formula for $t=25^0C$ and p=0.1MPa and a molten carbonate fuel cell we can gain the fuel cell efficiency of 85.2%, but for the reactions at $t=650^0C$ this coefficient of efficiency slightly decrease to 81.8%. These efficiencies are very high and can not be obtained in a real fuel cell that operates with approximately 50 to 60 percent of efficiency. Which for our syngas, and efficiency of a fuel cell of 55%, allows obtaining of 6412.6 kJ =1.78kWh electrical energy, which makes overall coefficient of efficiency 44.9%.

CONCLUSION

As it was expected, the system downdraft gasifier-fuel cell would be more efficient than the system downdraft gasifier-gas turbine. However, the lower cost of the system downdraft gasifier- gas turbine makes it more attractive. The purpose of this paper is to show the different possibilities for the use of the gas obtained from downdraft gasification for generation of electricity, and to evaluate the value of this gas for this kind of systems.

LITERATURE

[1] Karamarković V.**:** *Biomass combustion and gasification,* Faculty of mechanical engineering in Kraljevo, Kraljevo, 2003.

[2] Balmer Robert: *Thermodynamics,* West publishing company, 1990.

[3] Sharon Thomas, Marcia Zalbowitz, *Fuel Cells – Green power,* Los Alamos National Laboratory

[4] Darren D. Schmidt, Jay R. Gunderson: *Opportunities for hydrogen: an analysis of the application of biomass gasification to farming operations using microturbines and fuel cells,* University of North Dakota

[5]www.eere.energy.gov/hydrogenandfuelcells/ fuelcells/fc_types.htm – web presentation of the US Department of energy

REDUCTION AIR POLLUTION – REQUIREMENT STORAGE LIVING ENVIRONMENT AND PROVIDE QUALITY OF LIFE

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Abstract

Ecological problems in Užice are about air pollution, water pollution, ground pollution, imperilled health of people and unrational use of natural resources. Institution for protection of health in Užice measure concentration of air pollutants for many years. We affirm by analysis of results that soot, sulphur(IV)-oxide and sediment materials are continually present in Užice. One part of municipal contaminant come from heating (central and individual) and traffic, but another part come from process of production.

Key words: *ecological problems, protection of natural environment*

1. INTRODUCTION

Clean air is foundation for health and life of people and hole ecosystem. Because of industrial activities, traffic and heating, concentration of dangerous materials in air is in standing progress. Frequent air pollutants are showed on table 1.

Table 1. *Frequent air pollutants*

1.	sulphur(IV)-oxide
2.	nitric oxides
3.	organic volatile material
4.	chlorine
5.	ammonia
6.	hydrogen fluoride
7.	carbon bisulphide
8.	hydrocyanic acid
9.	carbon oxychloride
10.	vinyl chloride
11.	3,4-benzo-pyrone
12.	tetraethyl lead
13.	ozone and oxidation's medium
14.	aerosol
15.	soot

Purpose of this work is analyse of air pollution in life environment in industrial zone of Užice, in which the hospital is beside the factories. Results of measurement of air pollutants in life environment come from referee laboratories. We will give suggestions for reformation of quality of life environment.

2. RESULTS AND DISCUSSION

Krčagovo is industrial zone of Užice. Dangerous materials pollution work environment in factories located in this zone of Užice, in process of production. Because of obsolete technology of refinement and being systems are not observance for many years dangerous materials are portable in life environment. Factories are one of three most contaminant of atmosphere. Other contaminants are heating (central and induvidual) in winter and traffic because highway to downtown pass by Krčagovo (picture 1.).

Results received measurement air pollutants in life environment for four successive years are illustrated tabular: average monthly value (AMV) of concentration of sulphur(IV)-oxide and days with the biggest measure values (table 2), average monthly value (AMV) of concentration of soot and days with the biggest measure values (table 3) and average monthly values overall sediment materials (table 4).

We arrive to verdict by analyses of concentration of sulphur(IV)-oxide that pollution by sulphur(IV)-oxide in first year wasn't big. In second year measure concentration wasn't bigger than maximum permissive concentration (MPC). In winter of third year (in january, february and march) concentration of sulphur(IV)-oxide was or over MPC or they had smaller value than MPC. Altough in fourth year concentration of sulphur(IV)-oxide was smaller than third year, these two years were very similar by mode of change of concentration of sulphur(IV)-oxide. The biggest values of concentrations of sulphur(IV)-oxide were noted on 3. II in third year (197 $\mu g/m^3$) and 27. I in fourth year (169 $\mu g/m^3$).

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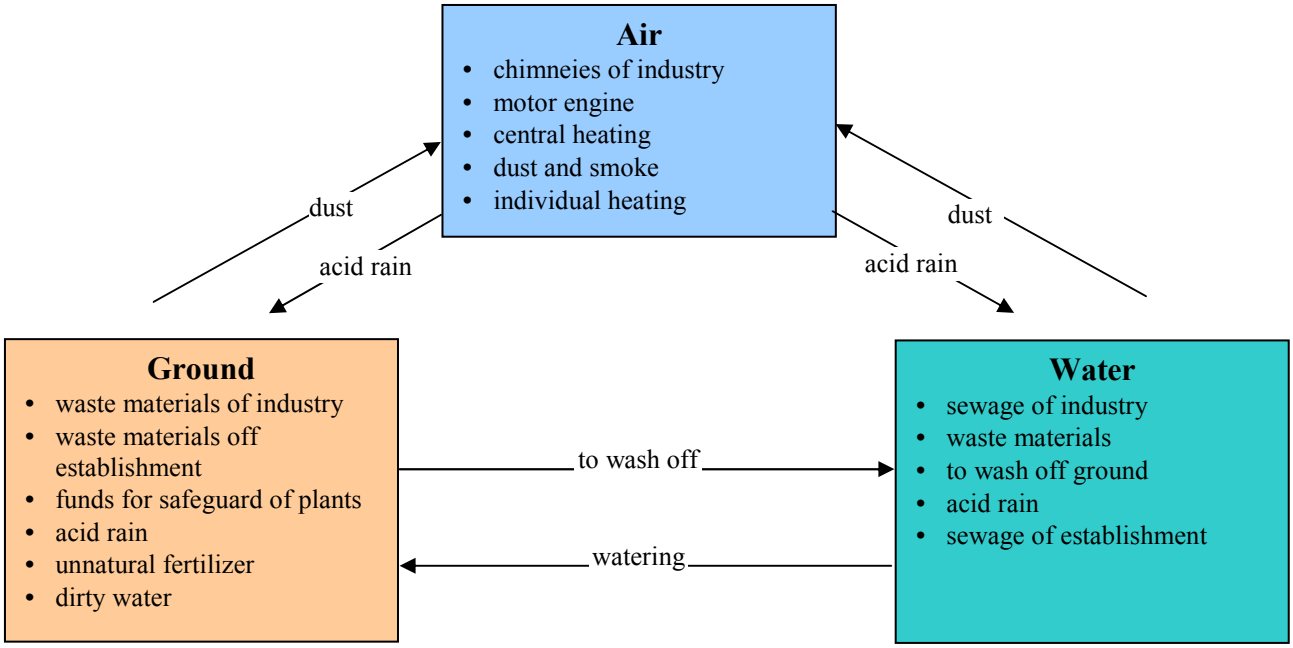
Analyses of resultes of measure of concentration say that concentration of soot was often bigger than MPC in all four years. Frequent overflow were in winter (from december to march) in first and second year. In that periods measure concentrations have value which are five time bigger than MPC. The biggest values of concentrations of soot were noted on 19. XII in first year (214 $\mu g/m^3$) and on 19. to 21. XII in second year (232 $\mu g/m^3$). The biggest average monthly value was noted in first month of first year.

We arrive to verdict by analyse of results of measure of sediment materials that they are present in all four year. Owerflows of MPC were noted mostly in spring and summer. The biggest owerflows are: VIII month of first year 703.10 $mg/m^2/day$, V month of second year 8725.83 $mg/m^2/day$ (measure value of all sediment materials is 19.39 bigger than MPC), IV month of third year 474.52 $mg/m^2/day$ and VI month of fourth year 565.70 $mg/m^2/day$. In winter of all four years measure values were in border of MPC. Exception is winter and XI month in third year when measure value was 465.50 $mg/m^2/day$.



Picture1. Cycle of pollution of life environment

Table 2: *Average monthly concentrations of sulphur(IV)-oxide and days with the biggest measure values*

$\mu g/m^3$	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	*MPC*
First year	-	-	-	-	31. **4**	14-18. **2**	29. **5**	-	-	-	-	19. **129**	**150**
AMV	-	-	-	-	0.52	0.6	0.16					28.90	
Second year	1-5. **82**	5. **87**	3. **124**	9. **58**	1-4. **10**	16. **14**	-	-	19-21. **12**	30. **70**	7-9. **138**	4. **110**	**150**
AMV	41.29	41.96	33.26	23.00	5.58	1.43	-	-	2.83	20.13	52.87	54.61	
Third year	13. **143**	3. **197**	30. **104**	1. **38**	14. **10**	-	-	11. **8**	15-16. **8**	28. **24**	19. **26**	21. **38**	**150**
AMV	63.35	39.61	39.61	14.5	1.00	-	-	0.71	0.77	4.52	15.23	18.71	

Fourth year	27. **169**	22. **78**	15. **25**	8. **13**	-	-	-	-	-	-	3. **10**	28. **14**	**150**
AMV	24.65	28.54	13.96	5.37	-	-	-	-	-	-	2.83	8.16	

Table 3: *Average monthly concentrations of soot and days with the biggest measure values*

µg/m^3	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	***MPC***
First year	11. **176**	2-4. **199**	13. **72**	30. **32**	9. **259**	21. **15**	2. **10**	12. **27**	12. **54**	21. **93**	28-30. **155**	19. **214**	**50**
AMV	83.7	73.4	22.0	17.6	20.5	5.77	2.23	9.26	18.3	39.97	55.67	80.68	
Second year	1-5. **168**	5. **192**	3. **94**	3. **38**	1-4. **25**	17. **26**	2. **22**	29-31. **25**	4. **64**	16. **47**	27. **119**	19-21. **232**	**50**
AMV	61.17	65.22	29.61	17.6	11.32	11.23	49.13	12.19	16.87	22.35	47.13	65.16	
Third year	19. **156**	16. **94**	24. **64**	1. **46**	21. **21**	8. **24**	20-30. **7**	7-9. **10**	16. **100**	23-25. **52**	3. **105**	28. **161**	**50**
AMV	52.19	50.72	30.29	15.54	10.74	6.85	5.61	6.84	17.3	23.77	28.67	48.77	
Fourth year	27. **150**	16. **56**	1. **40**	20. **17**	1-2. **12**	8 **6**	30-31. **7**	6-8. **12**	23. **19**	29-31. **8**	3. **8**	10-12. **5**	**50**
AMV	60.13	20.43	14.29	5.23	4.00	4.00	3.77	5.84	5.17	4.84	4.17	3.35	

Table 4: *Average monthly concentrations of all sediment materials*

µg/m^3	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	***MPC***
First year	173.93	186.47	133.65	55.95	122.28	59.19	114.35	703.10	45.33	15.20	191.42	155.85	**450**
Second year	192.41	121.13	176.39	289.23	8725.83	31.96	77.66	189.77	189.55	191.29	141.13	64.43	**450**
Third year	207.27	112.58	129.43	474.52	310.58	565.70	264.93	144.42	204.14	322.48	465.50	85.30	**450**
Fourth year	186.75	722.81	92.87	123.09	31.05	162.95	63.65	99.75	102.22	275.14	168.94	96.97	**450**

We detailed study attained data and view overall stage of life environment in looked industry zone. We arrive that stage is often very critical because concentrations of some dangerous materials are bigger than MPC. Because that is necessary to project safeguard with object to bring stage of concentrate of air pollution in MPC. Safeguard can be arrange on preventive and correction.

Preventive safeguards are:

- to shut construction of industry objects which are potential contaminants by methodical documents of Community
- to verify Study of rating of effect on life environment (for all potential contaminants)

- to do controls about integrity of car's engines (Police Department),
- to do constant control of industries chimneies and systems for refinement of air
- to import control of individual chimneies in private houses

Correction safeguards will be used when there are necessary. Ecological inspections, Eco-fund and Institution for protection of health should define correction safeguards.

Simultaneously, competent institution (ecological inspectors, Institution for protection of health and others) must secure constant control and tuition.

3. CONCLUSION

In industrial zone of city in looked time, it's noted continually presence of soot, sulphur(IV)-oxide and sediment materials in whole year. Concentrations of sulphur(IV)-oxide and soot in winter's months (december-march) are, sometimes, and five time bigger than MPC, during whole sediment materials are bigger than MPC mostly in spring's and summer's months (april-august).
In looked time, factories in Užice didn't do with full power. Their systems for air refinement have many faults. One part of municipal contaminant come from heating (central and individual) and traffic, but another part come from process of production. Uncontrol emission of air pollution relate to rise concentration of air pollutants in air which specific affect on quality of life. We arrive to verdict by analyse of results of measure of air pollutions in industrial zone of Užice that we must do preventive with construction of optimal devices for refinement and we must use system of preventive care by stage.

LITERATURE:

1. M. Miloradov, P. Marjanović, S. Bogdanović: „Metodologija za izradu integralnog katastra zagađivača životne sredine", „Agora", Beograd, 1995.
2. M. Kuborović, A. Petrov: „Zaštita životne sredine", SMEITS i Mašinski fakultet univerziteta u Beogradu, Beograd, 1994.
3. D. Veselinović, I. Gržetić, Š. Đarmati, D. Marković: „Stanja i procesi u životnoj sredini", Fakultet za fizičku hemiju univerziteta u Beogradu, Beograd, 1995.
4. „Menadžment totalnim kvalitetom", Nacionalni naučno-stručni časopis, Vol. 26, N^{o} 1, Beograd, 1998.
5. M. Đuričić: „Konsalting, inženjering i investicije", ICIM+,Kruševac, 2004.
6. Zakon o zaštiti životne sredine, Službeni glasnik RS 135/04, Beograd, 2004.
7. V. Rekalić: „Analiza zagađivača vazduha i vode" Tehnološko-metalurški fakultet univerziteta u Beogradu, Beograd, 1989.
8. Introduction to air pollution control, http://chppm-www.apgea.army.mil/desp/pages/samp_doc/aircontrol_intro/air_pollution_control.ppt,Washington,2004
9. D. Stanivuković, D. Šević, Od QMS do TQM, TQM, No2, Vol.31, Beograd, 2003.

ENERGY CRISIS AND PROTECTION OF HUMAN ENVIRONMENT

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Resume: One of the most important postulates of ecological society in the field of energetics is conservation , i.e., reduction in use of irrevocable natural resources, as well as the development of energy alternatives. Future of global and local developing strategy will depend on domination of mechanistic approach to reality and on projecting of ecological paradigm. For the beginning, identification of key interventions for protection of human environment, when we talk about domestic environment, is of the greatest importance.

Key words: *energy, ecological paradigm, pollution, human environment*

INTRODUCTION

Modern society, including domestic environment as its integral part, is faced with a complex problem of human environment pollution. It is a broad term which includes unwanted, dangerous changes in the characteristics of water, air, soil or food and which determine present and future of living beings. Eruption of technical-technological prejudices contribute to overall destruction of living environment. Fear of eco-acids open numerous questions to which modern society and science must give the answers. The most important one is: how to make the balance i.e., harmony between man and its environ. Although this answer is still being searched, it is clear that mechanism, reductionism, idealization, apocentrism are some notions that must be exceeded. However, holism, sense of responsibility, mental and spiritual reconciliation with nature, development of authentic needs are some notions whose realization will support a possible answer to the related challenge. The direction into ecologically-preserved society means the development of new energy solution together with overcoming of negative state of living environment.

PROBLEMS AND PROTECTION OF DOMESTIC LIVING ENVIRONMENT

The arsenal of burning problems, which deal with negative influence on the present sate of domestic living environment includes:

1. Trends in worsening of watersupply, sewerage system and control of wastes. So, 86,6% of population uses watersupply network which brings water directly to their homes or gardens, 88,3% has the access to the sewerage system of septic tanks; thus the infrastructure of watersupply is quite good, but there are some visible differences in providing services between regional areas, then rural and urban areas. Furthermore, in relation to wattersupply infrastructure and waste waters, the infrastructure of disposal of solid wastes considerably fell behind. In Serbia and Montenegro only 50% of waters is collected, there are no rubbish dumps which satisfy sanitary standards, all dangerous materials, starting from communal to toxic are disposed together. Impossibility of accessing to the systems of watersupply is a big health problem for poor settlements whose inhabitants are primarily internally displaced persons, Dipsies or refugees.

2. The state of coastal part of Montenegro is getting worse because ofuncontrolled building, lack of strategy of control over this area, lack of facilities for treatment of waste waters. The situations of bacteria infections are increasing and very often there are shortages of water during summer season. Ambitions of Montenegro to achieve 22 millions of tourists require elimination of these trends.

3. Black spots concerning air pollution are connected primarily with industrial zones: Pljevlja, Podgorica, Niksi' in Montenegro and kolubrsko-obrenovacki corridor in Serbia. A big source of pollution is the use of gasoline with lead addition and diesel fuel with high percentage of sulfur. In medium-term SCG should gradually stop using gasoline with lead addition and develop standards for provision of high quality gasoline.

4. Inefficient consumption of energy. Although the main cause of air pollution is burning of ignite of law quality in inefficient plants for production of energy which do not have necessary technology of pollution control, the situation becomes even harder due to high demand for these sources of energy by households and industry, which is caused by its low price. Restructure of energy sector together with gradual abolishment of subventions should result, after some time in larger investments in cleaner technologies, as well as in other activities for decreasing polluting effects created by energy production.

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5. Excessive industrial pollution. The most endangered black spots in Serbia are towns: Bor, Kragujevac, Pancevo and Sabac. These environments are contaminated by dichloroethane , mercury, heavy metals, pyralene oils, refinery wastes, phenols....
6. Institutional and legally inadequate system of living environment protection. Due to bad and antiproductive system of awarding, lack of supervision, monitoring of capacity for putting the law into effect by the Government authorities, unsatisfactory approach to information referring to living environment by the public, due to inaccessible capital which is to be used for improvement of technology. Strengthening of the system for control of living environment in SCG in combination with general reforms of state administration and efforts for decrease of corruption is necessary.

7. Boundary waters and global questions on living environment protection. SCG contributes about 13% in polluting the Danube by organic matters. In order to eliminate this problem, politics and support for decrease of pollution by organic matters in the sector of farming and improvement of treatment of rural and industrial waste waters in the Danube river basin.

8. Lack of preserved management of forestry. Our country possesses significant forest resources which are endangered because of unreasonable cutting, fires and attacks of pests. In this field, it was also shown as necessary to improve the management of forestry by strengthening of related industries, in order to provide increase of compensations for cutting of forests for covering the costs, then to make standards and regulations, both on international and domestic plan. (1)

TOWARDS ENERGY TURNING POINT

Condition for survival of each species is its adjustment to energy contents of the environment. Thus, only those forms which fit into energy matrix of the environment, i.e., whose energy is fitted with it, is able to secure their survival. Other species which ignore this rule are condemned to death. Living organisms, during the phase of the adjustment, pass first through colonizing, and then through climacteric phase. Precisely, because of the need for growth, for each biological form the imperative is maximal flow of energy from its own environment, while mature phase search minimal flow and uniform exchange of matters and energy with natural environment. Exploitation of environment of the environments and logic of growth shows that the mankind strongly stirred up into colonizing ambient without any wish to change it. However, all experiences show that if we do not pass into climacteric phase, we will eliminate chances for survival. Lack of energetic turning point, attitude that the modern technique and technology will prevent the planet to precipitate, and provide its further undisturbed robbing, then fast growing of its artificial needs opened numerous questions and the future depends on their answers. Solution was searched through institutional regulation of energy flow. But, bureaucratic atmosphere of economic and political institutions and their totalitarian and parasitic spirit made this problem more complex. With each stronger energy shake related institutions would undergo bigger expansion broadening their sphere of activity, power even more and shook the energy system which has been deeply broken. (2) So, the state in which modern society found itself could be characterized as the energy collapse. Fear of this catastrophe infects more and more the change of activity, habits and behaviour. Thus it becomes quite clear - without living nature the projected future becomes useless. Namely, nobody denies that owing to scientific achievements we succeeded in finding out a lot of things, starting from the chemical composition of human gene to cosmic worlds and microcosmos. Yet, besides all these grandiose discoveries remains the unsolved question: how to prevent degradation of human environment in the best way. (3) It is obvious that mankind must be freed from various rooted errors if it wants to change the state of human environment. In these rooted prejudices Grul includes:

- attitude that the world is endless
- attitude that our economy is based only on work and capital
- attitude that “an invisible arm” governs over all human actions
- attitude that the number and quality are on the first place
- attitude that material wealth is the only condition for fortune
- attitude that man has unlimited possibilities
- attitude that science and technique always serve to progress...(4)

In order to be freed from temptation of modern, i.e. idealistic picture of reality according to which the fortune is guaranteed end of history and postmodern for which all alternatives are used up, mankind must support ecological paradigm, that is, instinct for human holistic and friendly approach to life of nature – mechanistic combination must become past while the premises of entropy paradigm must be included into basis of abstract and active sphere. According to many authors the only possible platform of future will be jump into solar phase, for which the present form of industrial society is quite inadequate. Rifkin is warning: ”When we once realize deeper sense of transfer of energy phase of society with concentrated reserves (fossil fuels) on diffuse flow (solar energy) will obviously become our present industrial structure which can be used in solar future.”(2)

Previous practice and logic of industrial society was extremely hostile towards all alternative forms of energy. Investigations in this field were often blocked and destimulated by high costs and low prices of fossil fuels. Still with oscillations on the market of energy

sources the interest for energy alternatives becomes stronger. To present commercial and dominant energy sources the alternatives are natural and recoverable resources: energy of solar light, wind, water but also the strength of sea waves, tide and geothermal energy and even gravitation. (5)
Thus, breaking up with mechanistic approach is a must because "Our future is, no doubt, a solar future. The question is only if we will make useless attempts to produce highly technological solar energy base which will use a lot of raw materials and accelerate decay of the planet, build such a base which will tend in each phase to maintain energy flow and raw materials at the minimum."(2)

CONCLUSION

In order to provide undisturbed economic and spiritual life of a community the problem of human environment pollution must be treated in a good way. No ad-hoc methods and insufficient critic evaluation of abstract and active sphere cannot bring better situation. Ecological transformation of material culture of life production is to be done. In the interest of stating the real diagnosis of the adequate therapy in the field of projecting of preserved society, the most important is to analyze the most important problems and promote new qualitatively different alternatives.

LITERATURE

1. Environmental Sector Report: Serbia and Montenegro, Ministry for protection of natural treasures and living environment, Belgrade 2003.XIV, XII
2. J.Rifkin : "Lagging of future" ITRO, Naprijed, Zagreb 1986
3. W.Kruell, Verbruck Wissenschaft 2000
4. H.Grul "One planet is robbed" Prosveta, Belgrade, 1985
5. P.Djukic, M.Pavlovski "Ecology and society", Ecocenter Belgrade, 1999