BULETINUL INSTITUTULUI POLITEHNIC DIN IASI

Publicat de

UNIVERSITATEA TEHNICĂ "GH. ASACHI", IAŞI

Tomul LIV (LVIII)

Fasc. 3-4

Secția
ŞTIINȚA ŞI INGINERIA MATERIALELOR

2008

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
BULLETIN OF THE POLYTECHNIC INSTITUTE OF IAŞI
Tomul LIV (LVIII) 2008

MATERIALS SCIENCE AND ENGINEERING

CONTENT

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
BULLETIN OF THE POLYTECHNIC INSTITUTE OF IAŞI
Tomul LIV (LVIII) 2008

ŞTIINŢA ŞI INGINERIA MATERIALELOR

CUPRINS

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

ORIGINAL METHODS FOR DETERMINING THE THERMIC EXCHANGE BY RADIATION IN INDUSTRIAL ELECTRIC OVENS

BY

CRISTINA ALBU-IACOB

Abstract: Electrical ovens indirectly heated by resistor elements are for the present the main category of equipment for heat processing. That field is the most representative on the level of industrial utility. The main problem that concerns when analyse the opportunity of using electrical energy on heating in electrical ovens is that of the energy efficiency quantified by the efficiency of conversion of electrical energy into heat and the efficiency of heat transmission to the heated product. The paper presents original three-dimensional nomograms for determining form (view) factors which intervene in the calculation relation of the thermic flux transmitted by radiation (for the regular geometric surfaces) and the calculation by numerical methods of the view factors values (for the irregular geometric surfaces with various orientations too. The form (view) factors for different configurations of plane surfaces arbitrarily orientated in space are analytically calculated, starting from the general expression of the view factors for two surfaces. Such a calculus is extremely useful because it is directly connected to the thermic fluxes between the walls of the furnace and the pieces. The elaborated original three-dimensional nomograms offer the possibility to know the view factors for different typo-dimensions of plane surfaces and different orientations of the surfaces. By using numerical methods for the calculation of the view factors values we can use the automating computing and, this way, we can improve the heat change by radiation, by optimising the way to configure a charge in the working volume of the oven.

Keywords: electric ovens, heat transfer, radiation, view factors, three-dimensional nomograms.

The prevalent thermic exchange in the electric furnaces with indirect heating through resistors at high working temperatures and power densities, is the one through radiation.

In the next place the view (form) factors for different configurations of plane surfaces arbitrarily orientated in space are analytically calculated. Such a calculus is extremely useful because it is directly connected to the thermic fluxes between the walls of the furnace and the pieces.

For two surfaces S1 and S2 the view factor of the radiated surface S2 in proportion to the radiant surface S1, F1→2, has the expression given by the relation:

$$F_{1\to 2} = \frac{1}{S_1}\iint \frac{\cos\varphi_1 \cos\varphi_2}{\pi r^2} dS_1 dS_2 \qquad (1)$$

Further on, we shall take into account two particular cases:

- Two identical rectangular surfaces, parallelly arranged;
- Two identical rectangular surfaces, with a common side, perpendicularly arranged;

The case of two identical rectangular surfaces, parallelly laid:

The integral given by the relation (1) will become:

$$F_{1\to 2} = \frac{1}{\pi S_1}\int_{S_1}\int_{S_2} \frac{(x_2 - x_1)^2}{\left((x_2 - x_1)^2 + (y_1 - y_2)^2 + a^2\right)^2} dx_1 dx_2 dz_1 dz_2 \qquad (2)$$

We note with b and c the sides of the two rectangles and with a the distance between them and the relation (2) will get the expression:

$$F_{1\to 2}=\frac{2}{\pi}\left[\frac{a^2}{2bc}\ln\left(\frac{(a^2+b^2)(a^2+c^2)}{b^2+c^2-a^2}\right)+\frac{\sqrt{a^2+b^2}}{b}arctg\frac{c}{\sqrt{a^2+b^2}}+\right.$$
$$\left.+\frac{\sqrt{a^2+c^2}}{c}arctg\frac{b}{\sqrt{a^2+c^2}}\right]-\frac{2}{\pi}\left[\frac{a}{b}arctg\frac{c}{a}+\frac{a}{c}arctg\frac{b}{a}\right] \tag{3}$$

In figure 1 the dependence of the view factors F1→2 by the values of the b/a and c/a ratio is represented. As one can notice the view factor tends to the value for surfaces of big dimensions in proportion to the distance between them (b, c>>a).

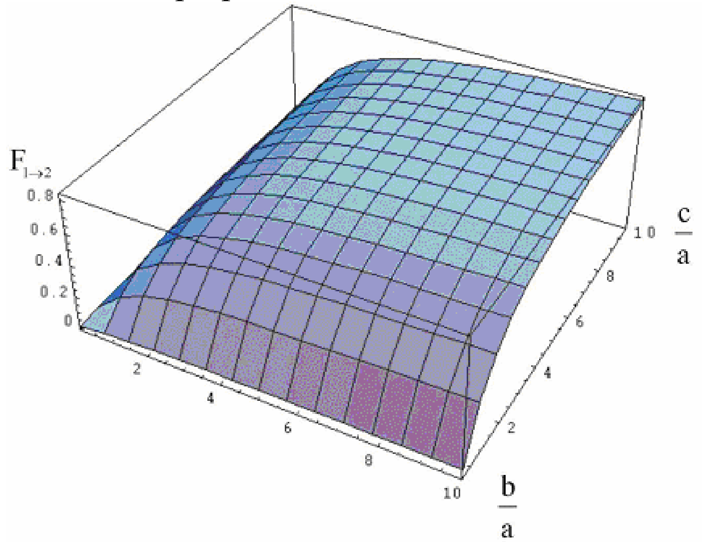


Figure 1. Graphical representation of the view factor $F_{1\to 2}$ by the values of the b/a and c/a ratio

In figure 2 the dependence of the view factor by the length of one of the sides in the case of those two rectangular surfaces and by the distance a between these two surfaces is represented.

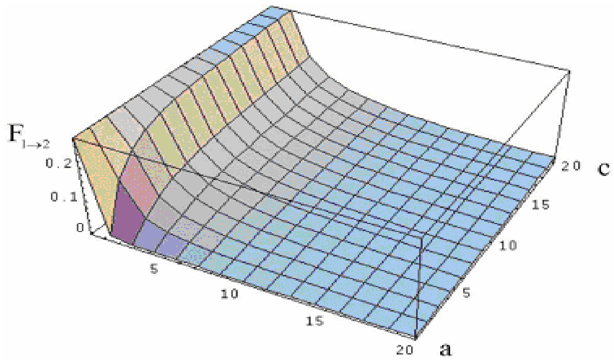


Figure 2. Graphical representation for the dependence of the view factor $F_{1\to 2}$ by the length of the side c and by the distance a, for the case b=1

The case of two rectangular surfaces with a common side, perpendicularly laid

The integral (1) gets, in this case, the expression:

$$F_{1\to 2}=\frac{1}{\pi S_1}\iint\frac{x_1 y_2}{\left(x_1^{\,2}+(z_1-z_2)^2+y_2^2\right)^2}dx_1dz_1dz_2dy_2 \tag{4}$$

Noting a, b, c the sides of two rectangles, where a is the common side, it results that:

$$F_{1\to 2}=\frac{a}{\pi b}\left\{\frac{1}{4}\ln\left[\frac{(a^2+b^2)(a^2+c^2)}{\left(a^2+b^2+c^2\right)}\left(\frac{b^2(a^2+b^2+c^2)}{(a^2+b^2)(b^2+c^2)}\right)^{\left(\frac{b}{a}\right)^2}\left(\frac{c^2(a^2+b^2+c^2)}{(a^2+c^2)(b^2+c^2)}\right)^{\left(\frac{b}{a}\right)^2}\right]\right\}+$$

$$+\frac{a}{\pi b}\left[\frac{b}{a}\operatorname{arctg}\frac{a}{b}+\frac{c}{a}\operatorname{arctg}\frac{a}{c}-\sqrt{b^2+c^2}\operatorname{arctg}\left(\frac{a}{\sqrt{b^2+c^2}}\right)\right] \tag{5}$$

In the figures 3,4, the dependence of the view factor by the b/a and c/a ratio (figure 3), and respectively by the b side and distance a, for c=1 (figure4) is represented.

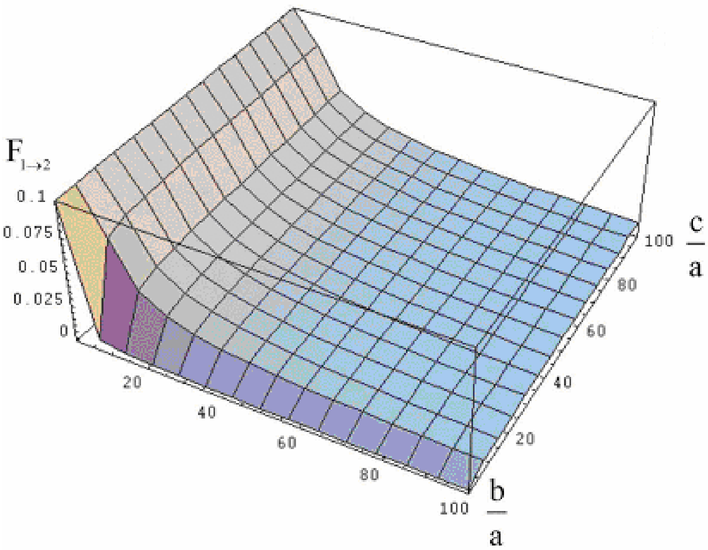


Figure 3. Graphical representation for the dependence of the view factor $F_{1\to 2}$ by the values of the ratios b/a and c/a

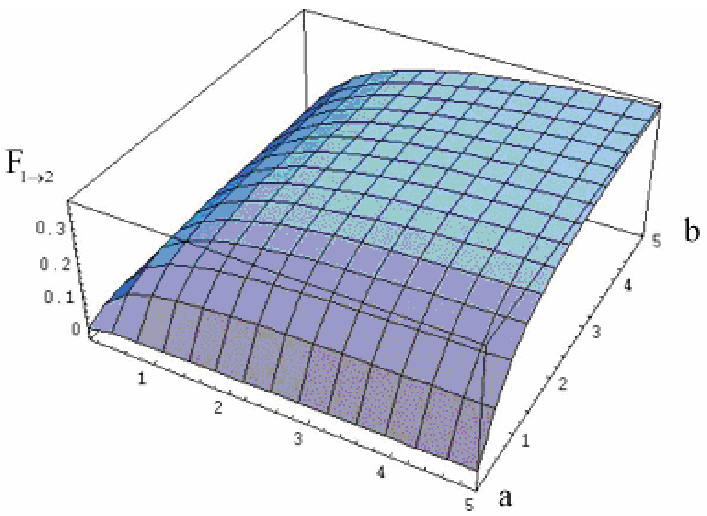


Figura 4 Graphical representation for the dependence of the view factor $F_{1\to 2}$ by the side b and side a, for c=1

For the electrical indirectly heated ovens by elements with high power density for the technological processing at high temperature, the heat exchange takes place mainly by radiation.

The 950 - 1200 °C resistant elements are correctly assimilated to infrared-ray spectrum emitters.

In thermodynamics, energy density is the quantity of heat radiated by a surface unit in time unit. The relation expressing the net exchange of energy radiation between two black bodies id *the Stefan and Boltzman* one:

$$\Phi_{ij} = \sigma S_i (T^4_i - T^4_j) \text{ [W]} \qquad (6)$$

where: S_i - surface of emitting body; σ = 5,67 x 10^{-8} [W/ m^2K^4], *Stefan's* constant; Ti…Tj - temperature of bodies between that exchanges heat [K].

Practically, in engineering, this relation has to be completed and adapted to real bodies that differ from the black ones way, the heat change by radiation is depending on the geometric shape of parts between exchanges take place, orientation of exchange arias and also of the fact that this radiation heat change effects all the surfaces from the chamber and reflected radiation brings its contribution.

On this fact, the relation expressing the heat exchange by radiation between two real surface of S_i and S_j arias becomes:

$$\Phi_{ij} = \sigma F(\varepsilon) F_{i\to j} Si (T^4_i - T^4_j) \text{ [W]} \qquad (7)$$

where: $F(\varepsilon)$ - Relation depending of emission factors ε_i , ε_j of the two materials surfaces that exchange heat by thermal radiation; $F_{i\to j}$ - geometric shape factor (view factor) of the "i" body with respect to "j" body.

For the box furnaces by chambers of different geometric shapes, in whose work volumes are placed charges for different shape and configuration, at a time there are more than two surfaces changing heat by radiation. The energy exchange takes place by direct radiation and also indirect radiation of reflection to surface.

Now, the analysis of heat transfer is done by taking advice of the energetic radiance of each surface. It is considered that all the bodies are opaque, on having uniformity of temperature and constant characteristics of emissivity and reflectivity to all over the surface.

There were defined two terms: **I - irradiation**, meaning the total incident radiation on a surface in unit of time on aria unit; **B - energetic radiance**, meaning the total of radiation leaving a surface in time unit and from aria unit.

It was admitted, for simplicity reasons, that B and I present uniformity all over the surface. This aspect can be a reason for an error because the grey - diffuse surfaces are not strictly corresponding to this condition; but this error can be tolerated. For a material surface "i", the energy balance is as follows:

energetic radiance = emitted energy + sum of the reflected radiation

So:

$$B_i = \varepsilon_i E_i + (1 - \varepsilon_i) I_i \text{ [W/m}^2\text{]} \qquad (8)$$

The net flux of radiant energy which leaves the surface S_i, respectively, the speed of thermal transfer is:

$$\Phi_i = (B_i - I_i) S_i = \varepsilon_i S_i / (1 - \varepsilon_i) (E_i - B_i) \text{ [W]} \qquad (9)$$

It is considered that surface "i" is radiating towards "j". The total irradiation consists in sum of all irradiation I_j from the "j" surfaces, and taking advise of the reciprocity property, that:

$$S_j F_{j\to i} = S_i F_{i\to j} \qquad (10)$$

and the fact that irradiation can be written as follows:

$$S_j\,B_j\,F_{i\rightarrow j} = I_j\,S_i \tag{11}$$

it becomes:

$$\Phi_i = \varepsilon_i S_i\,(E_i - \sum_j I_j) = S_i\,B_i - \sum_j F_{i\rightarrow j} B_j = \sum_{j=1}^{n}\Phi_{ji} = \sum_{j=1}^{n} S_j F_{j\rightarrow i}(B_j - B_i)[W] \tag{12}$$

from where:

$$B_i = (1 - \varepsilon_i)\sum_j F_{i\rightarrow j}B_j + \varepsilon_i E_i = \frac{1-\varepsilon_i}{S_i}\sum_j F_{j\rightarrow i}B_j + \varepsilon_i\,S_i E_i = \frac{1-\varepsilon_i}{1 - F_{i\rightarrow j}(1-\varepsilon_i)}\sum_{\substack{j\\ j\neq i}} F_{i\rightarrow j}B_j \tag{13}$$

In a system with several bodies and radiant media, the thermal emitted flux by radiation by on of the parts to the all others equalises the radiation of involved part. This fact generates the following relation:

$$\sum_{j=1}^{n} F_{i\rightarrow j} \cong 1, \text{ where } F_{i\rightarrow j} \in [0,1] \tag{14}$$

In the following, we analyzed the possibilities of calculation by numerical methods of the view factors values and also, this way, to improve the heat change by radiation, by optimizing the way to configure a charge in the working volume of the oven.

The thermal transfer function by radiation expression is:

$$S_i\,F_{i\rightarrow j} = \frac{1}{\pi}\int_{s_i}\int_{s_j}\frac{\cos\psi_i\cos\psi_j dS_i dS_j}{r^2} \tag{15}$$

from where, the calculation formula for geometric view factor:

$$F_{i\rightarrow j} = \frac{1}{S_i}\int_{s_i}\int_{s_j}\frac{\cos\psi_i\cos\psi_j dS_i dS_j}{\pi r^2} \tag{16}$$

Starting from *Green - Gauss's Theorem* for transforming a surface integral into a curve simple integral, we calculate the geometric view factors by a curve double integral:

$$F_{i\rightarrow j} = \frac{1}{2\pi S_i}\int_{C_i}\int_{C_j}\ln(r)\,dr_i\,dr_j \tag{17}$$

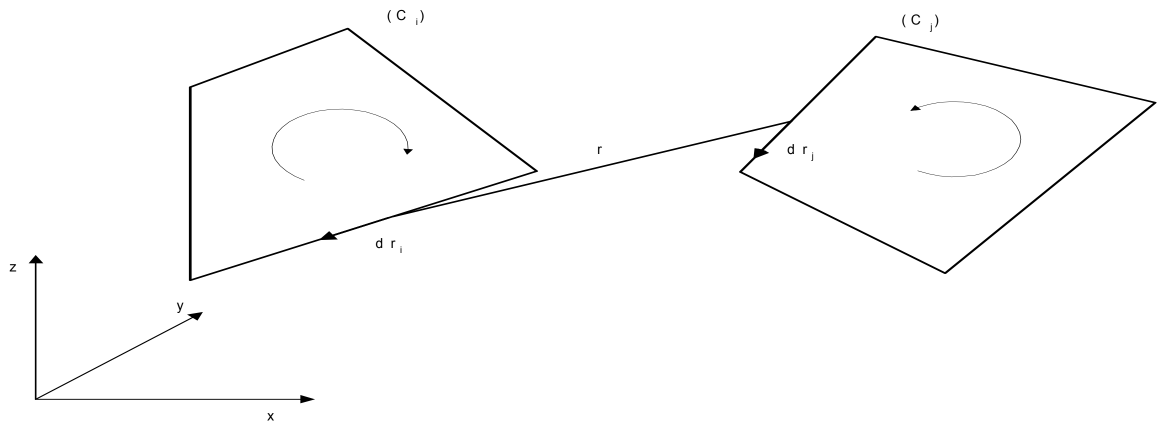
where: C_i, C_j - boundary curves of S and S_j surfaces; dr_i, dr_j - elementary lengths on C_i and C_j; r - distance between dr_i and dr_j .

It was adopted the well - known Romberg method for the calculus of an approximation of value of an integral through the limit of a time step to zero. Hereby, the procedure consists of two different steps:

- *First step*: the calculation of an approximation of the curve double integral by a successively application of the trapezoidal rule, with step size of h, h/2, h/4, for each segment on the boundary. This method is substituting the double integral by a double sum, as the following:

$$I^K = h_1h_2\,[\,\frac{f(a,c)+f(a,d)+f(b,c)+f(b,d)}{4} + \frac{1}{2}\sum_{\substack{j=1\\ \Delta i=2}}^{2^N-1}(f(a,c)+jh_2)+f(b,c+jh_2)) +$$

$$+\frac{1}{2}\sum_{\substack{i=1\\ \Delta j=2}}^{2^N-1}(f(a+ih_1,c)+f(a+ih_1)) + \sum_{\substack{i=1\\ \Delta i=2}}^{2^N-1}\sum_{\substack{j=1\\ \Delta j=2}}^{2^N-1}(f(a+ih_1,c+jh_{21}))\,] \tag{18}$$



where: a, b - limits for integration under r_1 direction (on C_1 boundary); c, d - limits for integration under r_2 direction (on C_2 boundary); $h_{iN} = (b-a)/2^N$ - integration step on C_1; $h_{jN} = (d-c)/2^N$ - integration step on C_2; k = i x j - number of application of double integral, $2^N = n$ - number of steps or successive application of the trapezoidal rule; dr_1, dr_2 - versors after r_1 direction to C_1 boundary, and r_2 to C_2 boundary.

- *Step two*: to accomplish Romberg extrapolation, using the recurrence relation, on the basis of I(n,1) values provided from the anterior step:

$$I(m,n) = I(m-1,n+1) + \frac{I(m-1,n+1) - I(m-1,n)}{4^m - 1} \qquad (19)$$

where :n, m - number of rows and columns of a diagonal matrix;

$$\begin{bmatrix} F_{11}F_{12}F_{13}......F_{1n} \\ F_{21}F_{22}F_{23}......F_{2n} \\ .... \\ .... \\ F_{n1}F_{n2}F_{n3}......F_{nn} \end{bmatrix}$$

For the case of intersecting plan surfaces, because of mathematical incompatibilities (such as possibility of ln(0)), when the distance between two increments is zero, there will be calculated an error factor that will be added to the Sum of view factors for all the rest of boundaries:

$$\zeta = -\frac{1}{2\pi S_1}\int_{r_1=0}^{L}\int_{r_2=0}^{L}|r_2 - r_1| dr_1 dr_2 = -\frac{1}{2\pi S_1} L^2[\ln(L) - 1{,}5] \qquad (20)$$

The case of curved surface demands the optimization of the contour increment that was considered linear. It is necessary to know the analytic form of the equation of the curve and discretised expression of the curved boundary.

- Hereby paper exemplifies the routine designed for the determination of the view factors on a particular case. The particularization demands for a charge and a furnace made by planar surfaces.

Program running steps***:***

- Vector matrix construction for the S_i surfaces $[S_i]$, $i \in [1,n]$;
- Dimensioning of the square matrix $\lfloor F_{ij} \rfloor$ $i, j \in [1,n]$;

➢ For each pair of points corresponding to each side of curves C_1 and C_2 it is calculated the set of logarithmic functions assimilated to "r" distance between two points from different segments of the two boundaries

$$\text{FUNCT: } f_i = f(r_1,r_2) = \ln\left[r(r_1,r_2)\right] \tag{21}$$

Construction of the integration limits sight for each side of each curve, distinctly: $[a,b]$and $[c,d]$

➢ First approximation of the curve double integral by successive application of the trapezoidal rule on $[a,b]$ and $[c,d]$ interval for n = 2N cycles. Thus,

- When N=0

$$I_{01} = \frac{(b-a)(d-c)}{4}\left[f(a,c)+f(a,d)+f(b,c)+f(b,d)\right] \tag{22}$$

- When N = 1 ..... N_{MAX}, it is applied the recurrence formula:

$$I_{N.1} = \frac{(N_{N-1.1}+\sum\ )}{4} \tag{23}$$

where:

$$\sum = \frac{(b-a)(d-c)}{4^{N-1}}\left(\sum{}_1+\sum{}_2+\sum{}_3\right) \tag{24}$$

$\sum_1, \sum_2, \sum_3$ terms on (13) equation.

➢ The convergence criterion used is:

$$\left|\frac{I_{N.1}-I_{N-1.1}}{I_{N-1.1}}\right| \le \Delta \tag{25}$$

Construction of the diagonal matrix using the recurrent extrapolation formula after Romberg's method:

$$I_{N.j} = I_{N+1.j-1} + \frac{I_{N+1.j-1}-I_{N.j-1}}{4^{j-1}-1} \tag{26}$$

$$\begin{vmatrix} I_{0.1}I_{0.2}I_{0.3}\ldots\ldots I_{0.j-1}I_{0.j_{max}} \\ I_{1.1}I_{1.2}I_{1.3\ldots\ldots}I_{1.j-1} \\ I_{2.1}I_{2.2}I_{2.2}\ldots\ldots \\ \ldots\ldots\ldots\ldots \\ I_{N-1.1}I_{N-1.2} \\ I_{N.1} \end{vmatrix}$$

➢ The most accurate value of the integral is corresponding to $\left[I_{0j\max}\right]$;

➢ Determination of view factors matrix between i and j areas, by formula:

$$F_{i\to j} = \frac{\sum I^{K}_{0.j_{max}}}{2\pi S_i} \tag{27}$$

and between "j" and "i" areas, using the following reciprocity formula

$$F_{i\to j} = F_{i\to j}\frac{S_i}{S_j} \tag{28}$$

➢ For the accuracy of the calculus, it is to verify the balance condition for the thermal exchange for each knot, as a consequence of the energy preservation law: $\sum_{i=1}^{n} F_{i \to j} \cong 1$, if that condition is not accomplished, then each term of the sum will suffer an adjustment by a corresponding proportionality factor.

We recommend this routine to be used as a unit on a complex structure of a program designed for modeling and simulation of industrial thermal processes on electric furnaces at high functioning temperatures, where heat transfer is mainly happening by radiation.

The purpose is to predetermine the evolution in time of the temperature on the processed charge, and also to determine the optimal structure of the treatment cycle that has to be programmed on real charge and to determine the optimal specific consumption of energy demanded for a complete and performing treatment accomplishing.

It was noticed a rapid convergence of the view factors calculation method to a 10^{-3} precision, being unnecessary more than 6 successive applications of the trapezoidal rule and Romberg extrapolations, too.

Received October 21, 2008

Technical College of transport, Piatra Neamț

REFERENCES

1. Branchu, K., Plard, C., **Modelisation des transferts thermiques dans un four electrique industriel**, Frace, 1994, p. 7 - 76
2. Falota, H., Radoi, R., **The Thermal Modellimg of Different Types of Charges**, *Romania,* Bucharest, 1994, p. 125.
3. Cristina Albu-Iacob- Teza de doctorat **Contributii privind imbunatatirea constructiv-functionala a instalatiilor de tratament termic al aliajelor de cupru**, Iasi, 2002

METODE ORIGINALE DE DETERMINARE AL TRANSFERULUI YTERMIC PRIN RADIAȚIE ÎN CUPTOARELE ELECTRICE INDUSTRIALE

Rezumat: Lucrarea prezintă nomograme tridimensionale originale de determinare a factorilor de formă, ce intervin în calculul relațiilor de transfer termic prin radiație şi a celor de calcul numeric a factorilor de formă pentru suprafețe neregulate, de tipo-dimensiuni diferite şi de diverse orientări.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

TITANIUM CARBIDES SUPERFICIAL LAYERS ON CARBON STEELS

BY

ADRIAN ALEXANDRU and CARMEN CEZARINA BURLIBAŞA

Abstract: The paper present experimental results of the author about titanium carbide depositions on the metallic pieces from carbon steel using electrical discharges. The method is relatively simple and not expensive. In experiment were used electrodes from titanium carbides sinterized by cobalt. Optimal values of the discharge process, for every electrode type, was deduced only during the experiments. The analysis of the phase's composition of the new-formed layers was performed by X-ray using a DRON - 3 diffractometer. The radiation was MoK_{α} with the wavelength α Mo = 0,7107 Å.

Keywords: deposition, microstructure, layer, discharge, diffraction.

1. Introduction

In many situations, is essential the physico-chemical properties of the superficial layers of steel pieces to be improved. A way of improving the properties of metallic materials is to superficially processing by electric discharge using a proper electrode.

The use of an active titanium carbides electrode as anode, allows to achieve on the surface of the carbon steel samples, this depositions, as well as layers with a complicated structure, resulted by microalloying and diffusion into the steel sample. The geometric and microstructural characteristics of the superficial layers achieved in experiments depend on the working parameters used in the processing procedure.

Optimal values of the discharge process, for every electrode type, are deduced only during the experiments.

The presence of titanium carbides on the surface of the steel samples or in their superficial layers will certainly lead to the increase the mechanical properties and the corrosion resistance of these samples.

2. Experimental work

The electric spark method's basic requirement is the electrical conductivity of the piece and electrode. This fact determines the use of metals, metallic alloys, metalloceramic materials and fire-proof compounds as electrodes and pieces.

The experimental method consists of the following operations:
- preparing the surface of the sample which has to be processed;
- setting up the working parameters (current intensity, vibrating frequency);
- choosing the electrode;
- the actual deposit process;
- final finishing the treated surface.

The electric spark processing begins by bringing the electrode (anode) near the piece electrode (cathode), and when the distance becomes smaller than the percolation threshold, an impulse electric discharge forms which ends when the electrodes touch. The last phase of the process begins when the pressure (given by removing the vibrating electrode) between the electrodes decreases, and ends when the electric circuit breaks off, at a distance greater than the percolation threshold (which is equal to the amplitude of vibration). Using an impulse generator, when the electrodes separate, an electric spark may or may not appear.

3. Experimental data

The sample surfaces 20 x 20 x 10 mm were fine restricted and then processed by electric spark using electrodes (ϕ = 3 mm) made of sintered carbides Ti15Co6. The impulse discharge regimes were : the 3rd regime with I_{SC} = 1.3 A and the 4th regime with I_{SC} = 1.8 A at a discharge energy W_i = 2.1 ÷ 3.4 J, impulse duration of approximately $9 \cdot 10^{-4}$ s and electrode vibrating amplitude of 0.3 mm. Processing 1 cm^2 of the sample's surface was completed in 45 s. Before and after sparking the sample masses were determined. After sparking, the roughness of the treated surface, thickness of the deposited white layer and of the diffusion substrate, and the $MHV_{0.1}$ microhardness were measured.

The samples type, the work conditions and the measured microhardness values are given in Table 1.

Table 1.

Sample	Electrode material	Working regime		Layer thickness [μm]	HV[daN/mm²]	
		I[A]	ν[Hz]		in layer	transitio n area
OLC 15	Ti15Co6	1.8	30	32	680	540
OLC 15	ϕ = 3mm	2.4	60	58	710	654
OLC 45	Ti 15 Co6	1.8	30	30	1190	980
OLC 45	Φ=3mm	2.4	60	60	1244	990

From Table 1 one can notice that the microhardness measurements indicate in OLC 45 samples (which have in their structure 0.45 % C) at the transition towards its basic structure area (under the layer). The microhardness is higher than in the structure. As a result of a fast cooling of the material due to acquiring the heat by the sample basic material

The analysis of the phase's composition of the new-formed layers was performed by X-ray using a DRON - 3 diffractometer. The radiation was MoK_{α} with the wavelength α Mo = 0,7107 Å.

The diffraction data for OLC 15 specimen are given in Table 2. The diffraction data for OLC 45 specimen are given in Table 3.

4. Conclusions

The electric spark method's basic requirement is the electrical conductivity of the piece and electrode. This method was used to superficially process samples of carbon steel.

Table 2.

No.	$2\theta_i$ [deg.]	θ_i [deg.]	d_{hkl} computed [Å]	d_{hkl} gauge [Å]	hkl	Phase
1.	17.40	8.70	2.40	2.41	110	Fe_2N
2.	28.36	14.18	1.45	1.52	220	TiC
3.	33.60	16.80	1.24	1.30	311	TiC
4.	35.60	17.80	1.16	1.16	233	Fα
5.	39.50	19.75	1.06	1.07	400	TiC

Table 2.

No.	$2\theta_i$ [deg.]	θ_i [deg.]	d_{hkl}computed [Å]	d_{hkl} gauge [Å]	hkl	Phase
1.	18.04	9.02	2.27	2.27	102	Fe_3C
2.	20.20	10.05	2.03	2.01	111	M
3.	33.65	16.75	1.23	1.23	102; 140	Fe_3C
4.	35.90	17.95	1.15	1.16	233	M
5.	39.20	19.60	1.06	1.07	400	TiC
6.	40.60	20.30	1.08	1.07	400	TiC
7.	44.30	22.15	0.94	0.96	420	TiC
8.	48.60	24.30	0.86	0.88	422	TiC

The sample surfaces 20 x 20 x 10 mm were fine restriked and then processed by electric spark using electrodes (ϕ = 3 mm) made of sintered carbides Ti15Co6. The microhardness is higher than in the structure. As a result of a fast cooling of the material due to acquiring the heat by the sample basic material.

The analysis of the phase's composition of the new-formed layers was performed by X-ray using a DRON - 3 diffractometer. The radiation was MoK_α with the wavelength α Mo = 0,7107 Å.

Received November 11, 2008 *Technical University "Gh. Asachi" Iaşi*

REFERENCES

1. Gheorghies, C., **Controlul structurii fine a metalelor cu radiatii X**, Ed. Tehnică, Bucureşti, 1990.
2. ***, **Ustanovska ELITRON 22**, Academia Nauk, Chişinău, 1991
3. Vermesan, G., **Tratamente termice**, Ed. Dacia, Cluj, 1987
4. Popescu, N., **Tratamente termice neconvenționale**, Ed. Tehnică, Bucureşti, 1990
5. Vermesan, G., **Tratamente termice**, Ed. Dacia, Cluj, 1987

STRATURILE SUPERFICIALE DIN CARBURI DE TITAN DEPUSE PE OȚELURI CARBON

Rezumat: Lucrarea prezintă cercetările experimentale ale autorului referitoare la analizarea structurii straturilor superficiale din carburi de titan sinterizate cu liant cobalt depuse pe diferite mărci de oțel. Realizarea de straturi din carburi de titan s-a făcut prin descărcări electrice în impulsuri de scurtă durată. Determinările structurale

cuprind determinări de microduritate prin metoda Vickers, determinarea grosimii straturilor superficiale obținute experimental precum şi analize calitative de fază prin difractometrie de radiații X efectuate pe un difractometru DRON – 3, cu tub de radiație cu anod de molibden.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

DEPOSED LAYERS WITH ABRASIVE WEAR RESISTANCE ON STEELS BY DUPLEX THERMAL TREATMENTS

BY

ADRIAN ALEXANDRU and CARMEN CEZARINA BURLIBAŞA

Abstract: In this paper work, the authors wants to present which is the influence of the thermic treatments before and after deposition and alloying by electrical spark upon the abrasive wear resistance.

Keywords: electric spark, electrode, layer, hardening.

1. Introduction

The surface engineering, as technical interdisciplinar science is a new concept who appeared in high developed industrial countries as a result of spectacular development of the surface treatments.

A definition of this concept was given by David Melford, prime vicepresident of The Institute of Metals (UK) and by Tom Bell from The University of Birmingham (UK): The surface engineering is in the essence a designed method for surface and sublayers of metals which are designed together as a system which confer good performances for metallic materials and which are non specific for any of them token separately.

The demanded properties for the superficial layer are different of those of basic metals and almost in contradiction with them. The technologies of superficial treatments or thin layers deposition have each at them some disadvantages so in current practices the use of the combination of two or more methods for increasing the performances is a trend today.

The duplex technologies permit to obtain metallic parts with variable properties in a large range which respond for the most exigently requirements. The electrical deposition by the electric spark method is very efficient (figure 1). The process of alloying and deposition by electric spark or inverse electroerosion has some advantages as: high adherence of the deposed layers, simple and cheap machines and technology, and some disadvantages as: large roughness of the alloyed surface, the appearance in superficial layers of the parts of the residual stress which decrease the wear resistance. The efficient combination of alloying and deposition by electric spark with a superficial thermic treatment can make disappear many of these disadvantages may disappear.

2. Method of work

The experimental researchers of the alloying and deposition by electric spark and determination of the influence of the thermic treatments before and after, upon the structural changes were made on the following steels:39MoAlCr15, 115MoVCr115, which are described in table 1.

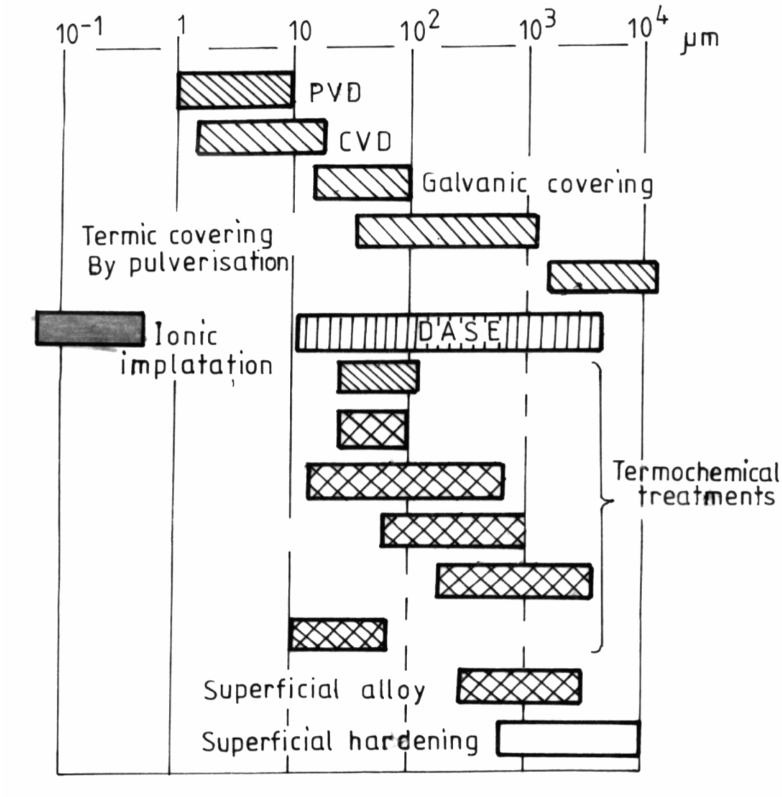


Figure 1. Superficial processing of steel

Table 1

Table	Steel type	CHEMICAL COMPOSITION, %										
		C	Mn	Si	P	S	Cr	Mo	Ni	V	Al	Cu
1	39MoAlCr15	0,41	0,52	0,34	0,025	0,020	1,57	0,21	0,18	0,03	0,98	0,2
2	155MoVCr115	1,58	0,41	0,22	0,021	0,025	11,7	0,72	0,16	1,05	0,03	0,23

Table 2

Steel	Variant	Electrode	$HV_{0,05}$, daN/mm²	Δm·g after time, in minutes						Δm_c, g	Vm, g/h	I_m, g/h·m³
				10	20	30	40	50	60			
39MoAlCr15	C-CIF+DAES	WCo8	1332	0,001	0,004	0,008	0,010	0,028	0,051	0,051	0,051	0,1869
		Ti15Co6	1079	0,001	0,005	0,01	0,012	0,036	0,064	0,064	0,064	0,2345
	E-DAES+CIF	WCo8	1097	0,002	0,006	0,018	0,024	0,032	0,082	0,082	0,082	0,3005
		Ti15Co6	949	0,002	0,011	0,020	0,039	0,053	0,124	0,124	0,124	0,4545
155MoVCr115	C-CIF+DAES	WCo8	2007	0,0008	0,001	0,004	0,006	0,0082	0,02	0,020	0,020	0,0733
		Ti15Co6	1686	0,001	0,002	0,008	0,01	0,013	0,034	0,034	0,034	0,1246
	E-DAES+CIF	WCo8	2690	0,0006	0,001	0,002	0,003	0,0054	0,012	0,012	0,012	0,04398
		Ti15Co6	2202	0,001	0,002	0,005	0,006	0,009	0,023	0,023	0,023	0,0843

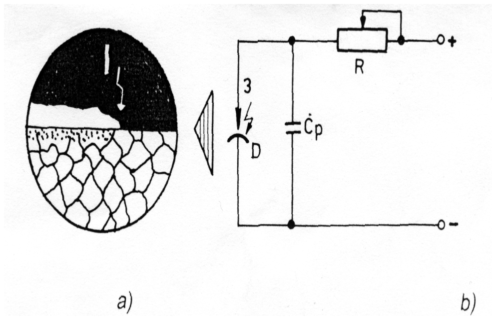


Figure 2. Superficial hardening by electrical spark: a) process; b) the device

Alloying and deposition by electric spark uses the inverse polarity – the part which is processed is the cathode and the electrode is the anode (figure 2) in this case the deposition takes place in air or other gas, with or without a rotation movement.

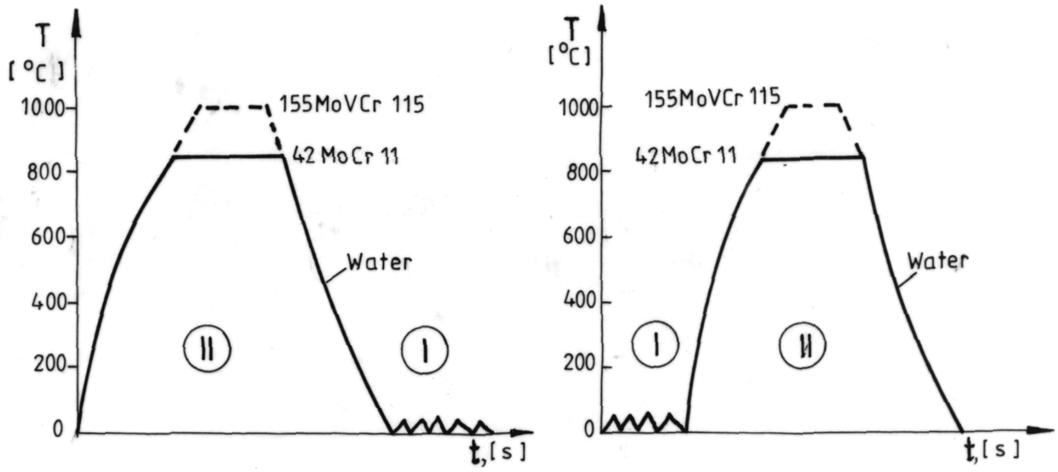


Figure 3. The duplex variants of treatment; a - depositing and alloying by electrical spark, b - superficial hardening by induction

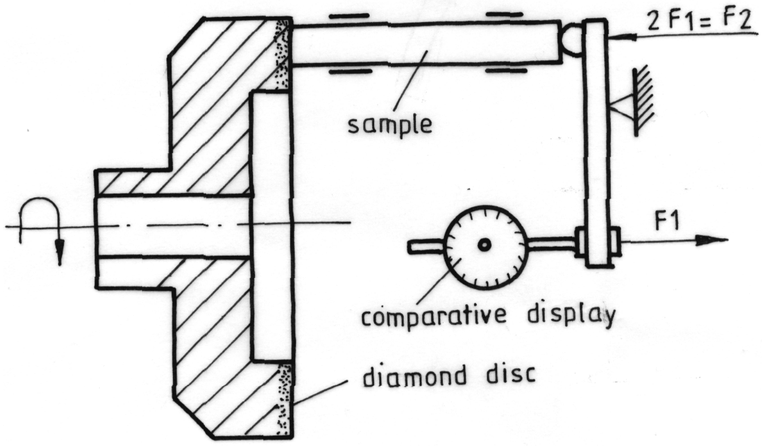


Figure 4. The device for abrasive wear testing

By comparing with other methods, the alloying and deposition by electric spark presents a series of advantages: the deposed metallic layer present a resistant connection with the basis material; the method makes possible the deposition of pure metals (Ni, Cr, Mo, W, Ti) or metallic alloys; it is not necessary a preliminary preparation of the deposition surface etc.

The samples from the two alloy steels were processed in two variants of duplex treatments:

a) superficial hardening+deposition and alloying by electric spark;
b) deposition and alloying by electric spark+superficial hardening (figure 3).

At the processing by deposition and alloying by electric spark there were used sinterizated electrodes from metallic carbides (WCo8, Ti15Co6). The samples from the two steels with sizes ϕ 8x60 mm, processed after duplex treatments were tested at abrasive wear. The device for abrasive wear test is presented in figure 4.

3. Experimental results

The wear resistance was determinated by the masic wear (V_m) defined by STAS 8069-87.

$$V_m = \frac{\Delta m_c}{t}, \text{ g/h} \qquad (1)$$

The intensity of masic wear is calculated with the relation:

$$I_m = \frac{\Delta m_c}{A_f \cdot L_f}, \text{ g/h·m}^3 \qquad (2)$$

A_f, L_f – the surface and the lenght of friction.

The hardiness, the masic loses Δm and Im for pressing the samples with a 20 N force by a total friction length of 5428 m of the two studied steels, processed by C and E variants with WCo8 and Ti15Co6 electrodes are presented in table 2 and figure 5.

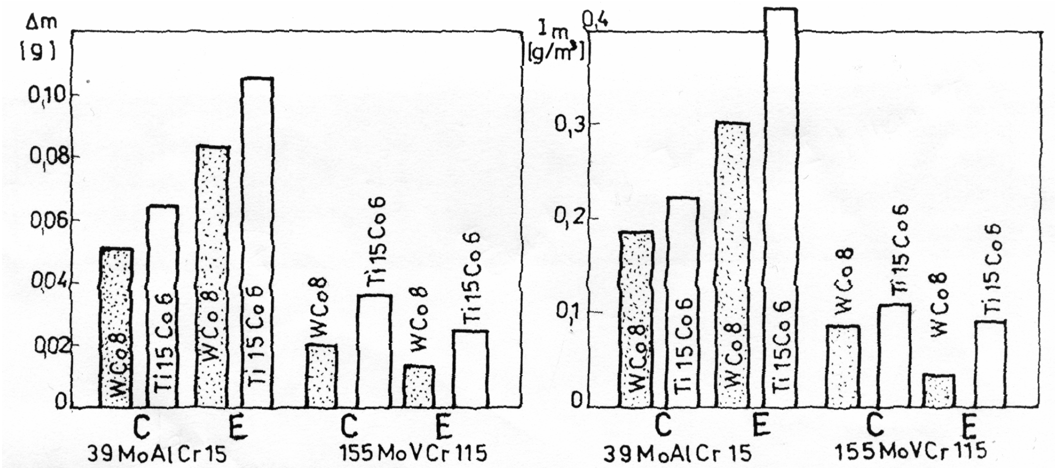


Figure 5.a) Δm; b)

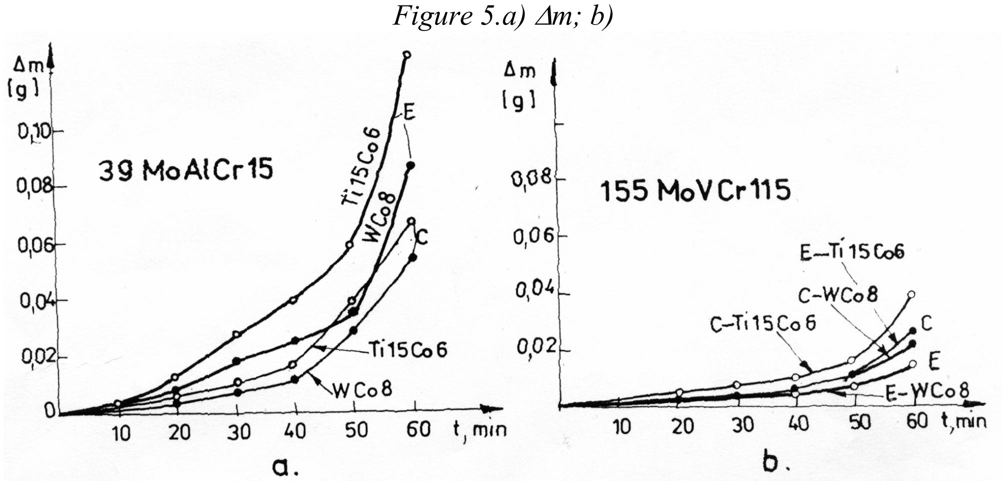


Figure 6. The variation of masic loses us time at friction for the steels 39MoAlCr15 and 155MoVCr115

The variation of masic loses during friction for the steels 39MoAlCr15 and 155MoVCr115 are shown in fig.6.

4. Conclusion

1) The high alloyed tools steel 155MoVCr115 which has in the deposed layers a verry large hardeness (1686÷2690 $HV_{0,05}$) present a very good abrasive wear resistance by comparing with the 39MoAlCr15 steel which has the microhardeness in the deposed layers only (949÷1332 $HV_{0,05}$);
2) The deposed layers with WCo8 electrode ensures a higher wear resistance as those deposed with Ti15Co6 electrode;
3) The duplex treatments variants which were applied at 39 MoAlCr15 steel at which the last operation was the deposition and alloying by electric spark (C variant induces higher wear resistance);
4) At the high alloyed tools, steel 155MoVCr115 higher wear resistances are obtained by the duplex treatment variants at which the last operation is superficial hardening.

Received November 11, 2008 **Technical University "Gh. Asachi" Iaşi*

REFERENCES

1. Alexandru, A. **Doctorate Thesis**, January 2002.
2. Alexandru, A., Pop, F. **Metallic materials with hardened deposit created by electric arc with vibrating electrode**. Proceedings EUROMAT-JUNIOR, Lausanne, 1994.
3. Pop, D., Pop, F., Alexandru, A. **Hardened deposition with tungsten carbides on steel specimens.** Proceeding, vol. II, EUROMAT, Lisabona, 1998.

STRATURI REZISTENTE LA UZURA DEPUSE PE OTELURI ALIATE PRIN TRATAMENTE DUPLEX

Rezumat: In aceasta lucrarea autorii prezinta care este influenta tratamentelor termice inainte si dupa depunere si aliere prin scanteie electrica asupra rezistentei la uzura.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

INFLUENCE OF THE NITROGEN SUPER-ALLOYING IN ELECTROLYTIC PLASMA UPON THE WEAR RESISTANCE OF OLC55 AND 40Cr10 STEELS

BY

MARIA BACIU

Abstract: Considering OLC55 and 40Cr10 steels, nitrided and quenched in electrolytic plasma, their wear resistance was expressed by means of the intensity (I_m) and rate (V_m) of mass wear.The thermal processing variants applied to the two steels under study comprised: three different diffusion temperatures, T_d= 650,700 and 750^{0}C; two values of the diffusion time $t_{d=}$ 3 and 6 min; the electrolyte with the composition: 10%NH_4Cl + 20% NH_4OH + H_2O.Based on the experimental data recorded for the two steels under study, the variation curves were plotted, as a function of the diffusion temperature, for the average mass wear rate, $\bar{v}_m = f(T_d)$ and for the average mass wear intensity, $\bar{I}_m = f(T_d)$.

Keywords: electrolytic plasma, steels, abrasive wear.

1. Introduction

Microstructural changes caused by the process of super-alloying by diffusion during steel heating in electrolytic plasma influence wear resistance.

Mass wear of materials can be expressed by means of the mass wear rate, V_m:

$$V_m = \frac{\Delta m_c}{t}, \text{ [g/h]} \tag{1}$$

and by the mass wear intensity, I_m:

$$I_m = \frac{\Delta m}{A_f \cdot L_f}, \text{ [g/m}^3\text{]} \tag{2}$$

where: Δm_c represents cumulated mass loss, Δm - mass variation, t – time, A_f - friction surface and L_f – length of the friction path.

2. Experimental

The technological variants of the nitriding treatments applied to OLC55 and 40Cr10 steels are shown in Figure 1.

Wear behaviour of OLC55 and 40Cr10 steels, super-alloyed with nitrogen by heating in electrolyte solution has been studied under the conditions of a dry wear regime between the contact surfaces of the specimens and the diamond disk, Figure 2

The specimens, subjected to the wear tests, were super-alloyed with nitrogen in electrolytic plasma according to the conditions given in Table 1.

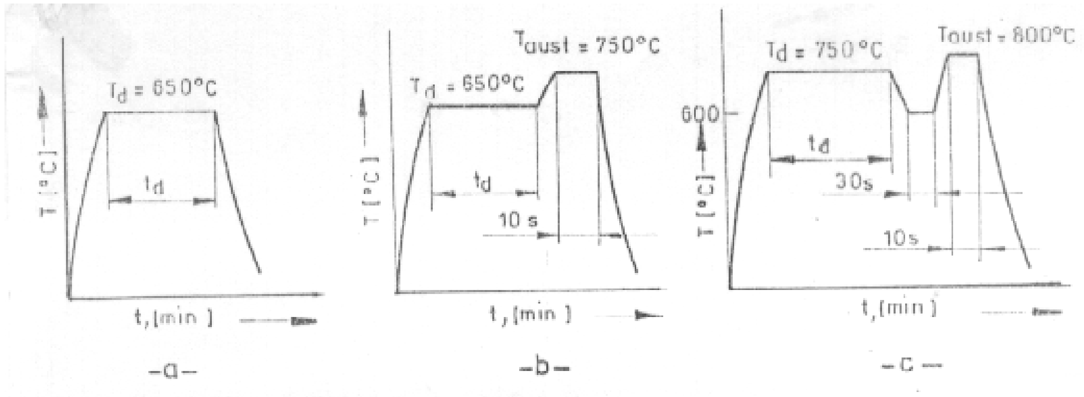


Figure 1. Technological parameters of the nitriding treatments by heating in electrolytic plasma; variant a – nitriding (T_d = 650^{0}C, t_d = 3; 6 min) and quenching; variant b – nitriding (T_d = 650^{0}C, t_d = 3; 6 min), followed by heating for austenitization (T_{aust} = 750^{0}C, t = 10 sec) and quenching; variant c – nitriding (T_d = 750^{0}C, t_d = 3; 6 min) followed by a quenching step (600^{0}C, t = 30 sec) then heating for austenitization (T_{aust} = 750^{0}C, t = 10 sec) and quenching.

Wear behaviour of OLC55 and 40Cr10 steels, super-alloyed with nitrogen by heating in electrolyte solution has been studied under the conditions of a dry wear regime between the contact surfaces of the specimens and the diamond disk, Figure 2

The specimens, subjected to the wear tests, were super-alloyed with nitrogen in electrolytic plasma according to the conditions given in Table 1.

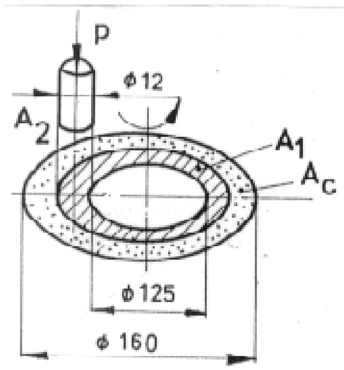


Figure 2. Conditions specific to the abrasive wear test (V_{slip} = 1.25 m/min, p = 1.5 MPa).

Table 1

No.	Steel grade	Marking	Technological parameters of diffusion		Initial mass, m_i, [g]
			T_d, [^{0}C]	t_d, [min]	
1	40Cr10	3R	650	3	40.3547
2		3I	700		40.4266
3		3M	750		40.5210
4	OLC55	4D	650		40.7285
5		4F	700		40.7407
6		4S	750		41.1910
7	40Cr10	3A	650	6	40.6015
8		3V	700		39.1349
9		3J	750		40.6167
10	OLC55	4Y	650		40.3947
11		4DD	700		40.9206
12		4T	750		40.4801

Obs.: electrolyte: 10%NH_4Cl+20%NH_4OH+H_2O; after nitriding all specimens were quenched.

3. Results

Measurements of the mass losses, Δm and Δm_c, were performed by weighing the specimens on the analytical balance, at different time intervals (1; 2; 2.5; 3; 3.5; 4, 4.5 and 5 hours) of the test.

Based on the relationships (1) and (2) the values of mass wear rate and mass wear intensity, respectively, were determined and subsequently the average values of these parameters were calculated, (Table 2).

Table 2

Average values	Specimen											
	3R	3I	3M	3A	3V	3J	4D	4F	4S	4Y	4DD	4T
$\overline{V_m}$	8.66	12.71	18.06	8.11	14.38	19.23	18.66	18.98	20.82	11.56	13.72	20.11
$\overline{I_m}$	6.503	10.802	13.568	6.094	9.544	14.445	14.014	14.252	15.633	8.683	10.301	15.105

The variation of the two mass wear parameters, $\overline{V_m}$ and $\overline{I_m}$, as a function of the diffusion temperature, is shown in Figure 3 and 4, respectively, for the two steels under study.

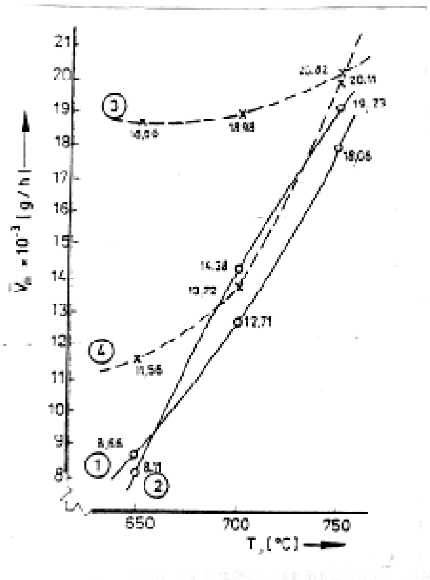


Figure 3 *Variation of the average mass wear rate,* $\overline{v}_m = f(T_d)$*, as a function of diffusion temperature:*

$$t = 3\,\text{min} \begin{cases} 1 - 40\,Cr\,10 \\ 3 - OLC\,55 \end{cases}$$

$$t = 6\,\text{min} \begin{cases} 2 - 40\,Cr\,10 \\ 4 - OLC\,55 \end{cases}$$

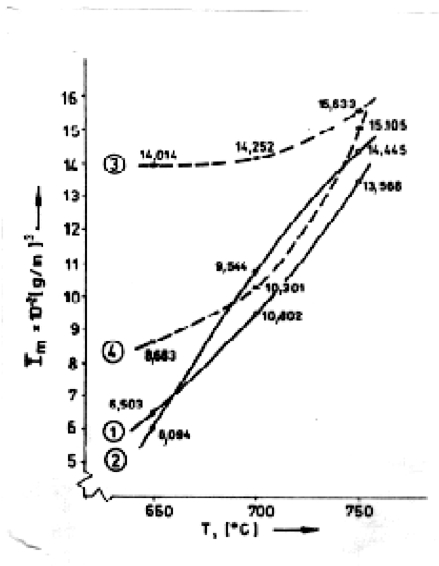


Figure 4 *Variation of the average mass wear intensity,* $\overline{I}_m = f(T_d)$*, as a function of diffusion temperature:*

$$t = 3\,\text{min} \begin{cases} 1 - 40\,Cr\,10 \\ 3 - OLC\,55 \end{cases}$$

$$t = 6\,\text{min} \begin{cases} 2 - 40\,Cr\,10 \\ 4 - OLC\,55 \end{cases}$$

4. Conclusions

(i) Nitrogen super-alloying of steels, heated in electrolytic plasma provides considerable improvement of wear behaviour, in dry friction regime.

(ii) Under the condition of maintaining constant the diffusion time, the lowest values of the parameters of wear process correspond to $T_d = 650^0$C; the increase of diffusion temperature causes the gradual increase of mass losses Δm and Δm_c.
(iii) By comparing the above two values of the diffusion time, better wear behaviour has been noticed for the specimens which were thermally processed for 6 minutes.
(iv) The analysis of the experimental data emphasizes the superior wear behaviour of 40Cr10 steel as compared to OLC55 steel under the conditions of the same values for the parameters of diffusion process.

Received November 20, 2008 *Technical University "Gh. Asachi" Iaşi*

REFERENCES

1. Aleksandrov, V.N. Ignat'kov, D.A., Pasinkovskÿ, E.A., **Fizico-mehaničeskie svojstva stali 45, azotirovannoj v èlektrolitnoj plasme, Elektronnaâ obrabotka materialov**, nr. 2, p.17-18, 1982.
2. Baciu Maria – **Contributions on the structural and property changes of thermally and thermochemically treated steels in electrolytic plasma** (in Romanian), PhD thesis, „Gh.Asachi" Technical University from Iaşi, 1999.
3. Belkin, P.N, Ignat'kov, D.A., Pasinkovskÿ, E.A., **Azotirovanie v elektrolitnoj plazma, Kolloquium Eigensspannungen und Oberflächen-verfestigung**, p.265, 1982.

INFLUENȚA ALIERII CU AZOT, ÎN PLASMĂ ELECTROLITICĂ, ASUPRA REZISTENȚEI LA UZARE A OȚELURILOR OLC55 ŞI 40Cr10

Rezumat: Luând în considerare oțelurile OLC55 şi 40Cr10 nitrurate şi călite în plasmă electrolitică, rezistența lor la uzare a fost exprimată cu ajutorul intensității de uzare masică (I_m) şi vitezei de uzare masică (V_m).Variantele de prelucrare termică aplicată celor două oțeluri din studiu au cuprins: trei temperaturi de difuzie diferite, T_d= 650,700 şi 750^{0}C; două valori ale timpului de difuzie $t_{d=}$ 3 şi 6 min; electrolitul cu compoziția: 10%NH_4Cl + 20% NH_4OH + H_2O.Pe baza datelor experimentale obținute pentru cele două oțeluri din studiu, curbele de variație au fost reprezentate grafic, ca funcție a temperaturii de difuzie, pentru viteza medie de uzare masică $\bar{v}_m = f(T_d)$ şi pentru intensitatea medie de uzare masică, $\bar{I}_m = f(T_d)$.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

RESEARCHES REGARDING ALUMINUM ALLOYS HARDENING THROUGH CYCLIC AGEING

BY

ROXANA-GABRIELA CARABET, CARMEN NEJNERU and ADRIAN COMANECI

Abstract: Some 7xxx heat treatable aluminium alloys were used for testing. These alloys were solution quenched at 560^{o}C followed by precipitation. The time of exposure realized at 8 hours with air-cooling. A sample, after solution quenching, was submitted to a cyclic ageing regime. The measurements realized at the microhardness tester with 100 g as weight. There were also made optical photographs of samples' structure.

Keywords: cyclic ageing, hardening, heat treatable.

1. Introduction

A supplementary and extreme way of increasing mechanical resistance of the alloys is represented by heat treatments based on phasic transformations in solid state. The main reactions that underlie these hardening heat treatments are precipitation from oversaturated solid solutions and eutectoid decomposition. A great number of technical alloys due their properties to the treatment applicability possibilities. These heat treatments consist in solution quenching, precipitation or ageing.

The structure of the aluminum alloys with practical interest, in equilibrium state is made of a "solid solution" matrix where different intermetallic phases are dispersed.

The studied aluminum alloy pertains from the remarkable members of 7xxx series and is an Al-Zn-Mg-Cu alloy.

In the paper verifies the efficiency of a special heat treatment of ageing, precisely cyclic ageing, with well defined cycles comparatively to classic ageing.

2. Experimental results

Some aluminium alloy samples (figure 1)were used for experiments with the chemical composition found in table 1.

Figure 1. Sample of 7075 T650 aluminium alloy

Table 1. Chemical composition of the samples 7075 T650 aluminum alloy

Al %	**Zn %**	**Mg %**	**Cu %**	**Cr %**	**Fe %**
90.3	5.41	2.26	1.50	0.223	0.169

The samples were heat treated in UTTIS which is a heat treatment furnace.

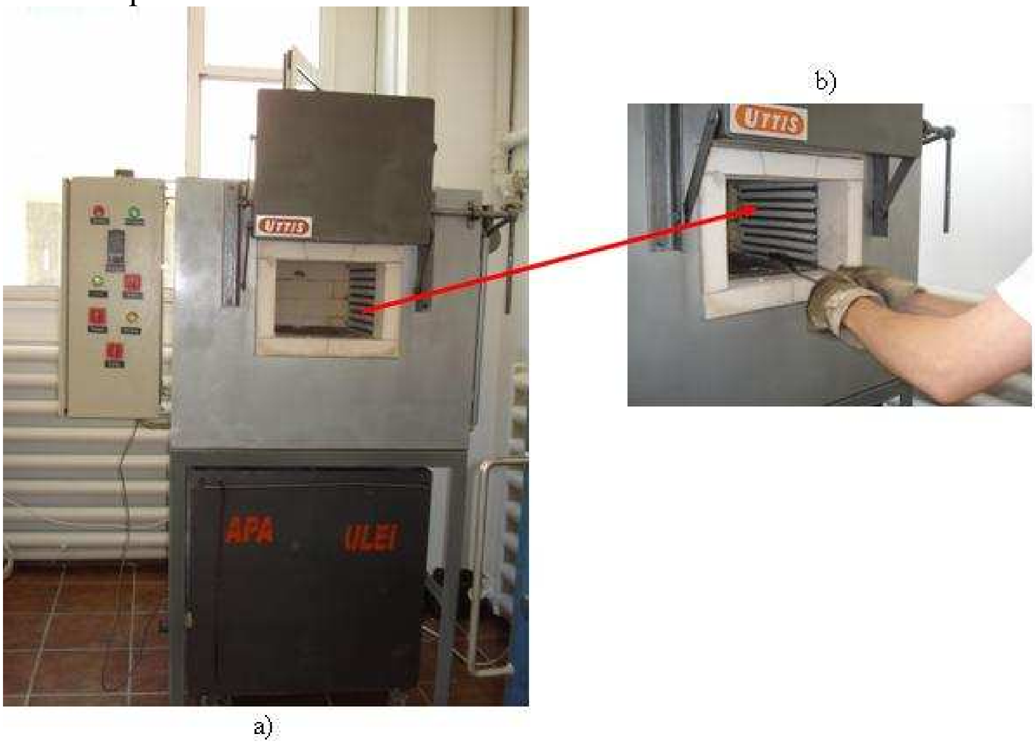


Figure 2. a) Heat treatment furnace-general view;b) Samples' removal

Samples were solution quenched at T = 560^{o}C, holding time for 1 hour and water cooling at 60^{o}C.

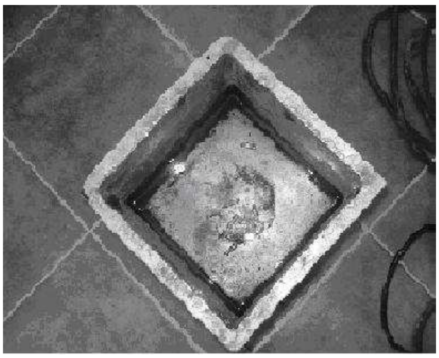


Figure 3. Tank for samples' cooling

If the samples were solution quenched, the artificial ageing treatment did with differential holding time:

- holding for 8 hours at 180^{o}C;
- cyclic – holding for 1 hour at 180^{o}C→10 min water cooling – 4 complete cycles

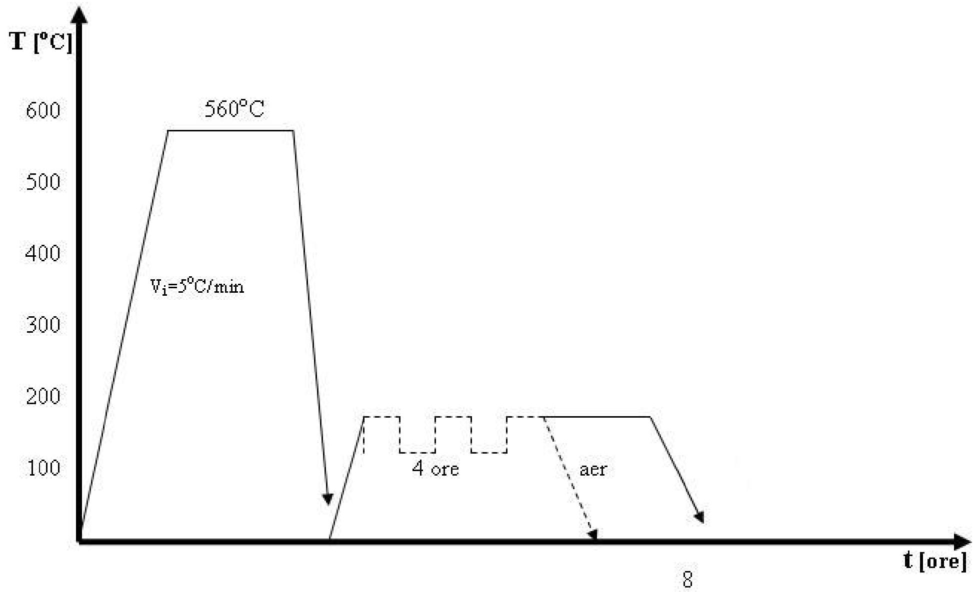
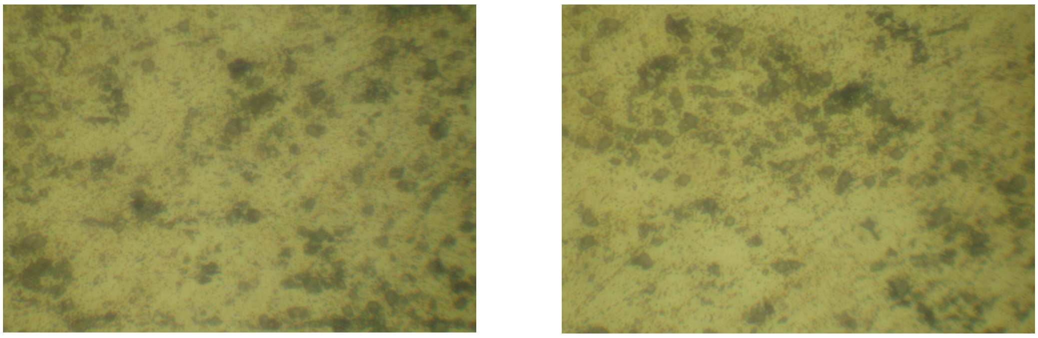


Figure 4. Complete diagram of heat treatment (solution quenching + artificial ageing)

Thus, treated samples were metallographic prepared and structure photos achieved.



a) b)

Figure 5. Metalographic photos of the samples

Also, there were made some measurements on PMT3 microhardness apparatus and data were centralized into a table, namely table 2.

Figure 5. PMT3 microhardness apparatus

Table 2. HV 100 microhardness measurement for the samples of T 751 7050 aluminum alloy

No.	Treatment type	Cone impression value				Microhardness value
		1	2	3	Average	
1.	Sample solution quenched at T_m=560˚C Water cooled at 60˚ and aged at T_m=180˚C for 8 hours	190	192	188	190	 **55,40**
2.	Sample solution quenched at T_m=560˚C Water cooled at 60˚ and cyclic aged at T_{m1}=180˚C, for one hour T_{m2}=20˚C, for10 minutes	171	179	162	176,66	 **68,66**

3. Conclusions

It notices that on the score of the artificial ageing treatment the sample cyclic aged gets maximum value of microhardness: HV = 68,66. The main advantage of cyclic ageing is shortening of treatment period from 8-14 hours without diminishing treatment's effect.

Received November 30, 2008

Technical University "Gh. Asachi" Iaşi

REFERENCES

1. Cavazos J.L., Colas R., **Precipitation in a heat-treatable aluminum alloy cooled at different rates**, Materials Characterization 47 (2001), 175-179;
2. Geru N., **Metalurgie fizică**, Editura Didactică şi Pedagogică, Bucureşti, 1981;
3. Carabet Roxana-Gabriela, Nejneru Carmen, Dima A., Rotaru G., Hopulele I., **Experimental heat treatment installation for cyclic ageing of the aluminum alloys**, Buletinul Institutului Politehnic Iasi, Tomul LIII (LVII), Fasc. 3, Sectia Stiinta si Ingineria Materialelor, Academia Romana – Filiala Iasi, 2007.

CERCETĂRI PRIVIND DURIFICAREA ALIAJELOR DE ALUMINIU PRIN ÎMBĂTRÂNIRE CICLICĂ

Rezumat: Câteva aliaje tratabile din seria 7xxx au fost folosite pentru experimente. Aceste aliaje de aluminiu au fost călite de punere în soluţie la 560^{o}C, urmată de tratament de îmbătrânire artificială. Tratamentul de îmbătrânire a durat 8 ore cu răcire în aer. Una dintre probe, după ce a fost călită de punere în soluţie, a fost supusă unui tratament de îmbătrânire ciclică. Măsurătorile s-au realizat la microdurimetru, folosindu-se o greutate de 100 g. De asemenea s-au realizat fotografii metalografice ale structurii.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

DAMPING CAPACITY OF METALLIC MATERIALS

BY

NICANOR CIMPOEŞU, ION HOPULELE, DRAGOŞ ACHIŢEI, VASILE MANOLE, RAMONA HANU CIMPOEŞU

Abstract: Big internal friction means big energy dissipation or big amortisation properties which influence a lot the metallic material resonance. This paper presents a study about internal friction (IF) properties of some metallic materials which can be used in different applications as damping materials. The investigation take place using torsion pendulum and the analyzed materials are different metallic compounds or alloys with big or small value of internal friction. To study internal friction of a material we have to respect the big differences of IF peaks that appear in material in austenitic or martensitic range.

Keywords: internal friction, damping capacity, torsion pendulum

1. Introduction

If we consider a string with length one, fixed at both parts and she is topping transversal vibrations will propagate in string length and this perturbations reflect on fixed ends and this way it's forming a stationary wave. Vibration proper modes of string are in this way controlled and they give birth to some longitudinal waves in ambient air which transmit them to ours ears like a musical sound.

Any body which vibrates can serve as elastic waves source in his medium, namely can be a sound source. When we produce vibrations in this string in places where is fixed, to her ends, are forming nodes and in the string middle will form a anti-node's. For this vibration are corresponded a certain frequency. If without this stationary wave can be stabilize in string a stationary wave with three nods: two at ends and one in the middle to this vibration will correspond a different frequency twice bigger then first one. In the same mode we can think for four nodes or even more. Therefore the same string can emit sound vibrations not only with fundamental frequency but also with so called superior harmonics (superior's tones). Sonant string is the sonorous source for all string instruments and all of them send sound directly or by resonance box and have a essentially importance for sound quality. The intensity of emitted sound is determinate by vibrations amplitudes of sonorous system.

On metallic materials properties a certain characteristic, named internal friction (IF) influence in a special way vibration capacity of that material. All sounds characteristics will depend of this property and on his evolution with temperature.

2. Internal Friction

The influence of material internal friction is bound of his amortization capacity so materials with big amortization capacity, due to them big internal friction, can't have nice applications in many industry fields because of their loose of sound resonance. So if we want to investigate some new materials for musical strings, amortization elements, shape memory alloys applications we have to pay attention to them internal friction.

Internal friction is measured frequently with a system moved with certain amplitude and after that left free to vibrate so the amplitude will decrease [1]. Amplitude after a matter of time t can be calculated by relation:

$$a_t=a_o e^{-\beta t} \qquad (1)$$

where β is an attenuation coefficient. The most common define way of internal friction or amortization capacity is to use logarithmic decrement δ. Logarithmic decrement is the logarithm of two successive amplitudes ratio, which can be see in figure 2[1]:

$$\delta=\frac{1}{n}\ln a_n/a_{n+1} \qquad (2)$$

In figure 2 the vibration amplitude of a metallic material with time graph is present and the amortized oscillatory movement made is the internal friction characterization of that material:

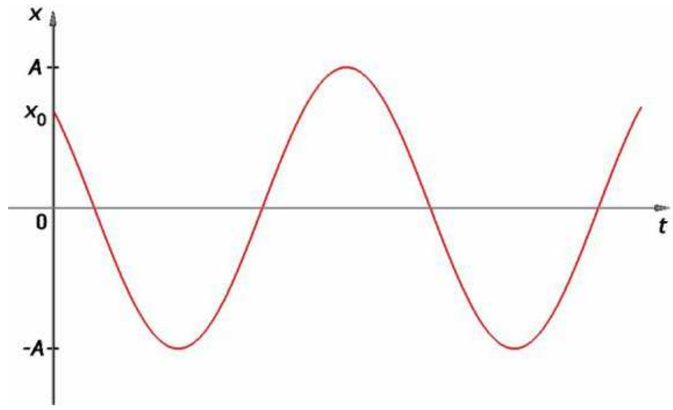


Fig. 1 Amplitude versus time graph.

Internal friction at metals has many phenomena for this behavior at microscopic scale. Because of internal friction nature we can change this term friction with amortization like in English language or German (damping or dampfung).

Internal friction causes are:

- thermo-elasticity
- conduction electrons
- magnetic phenomena's (structural defects of crystalline mesh (punctiform defects which create the diffusion phenomena's, linear defects as dislocations, dimension M defects which are grains boundary).

Mechanical amortization of materials is caused by irreversible mechanical energy transformation in thermal energy and has the same name with internal friction.

If ΔW represent energy looses in a full oscillation and W is the system mechanical energy we can define the internal friction as:

$$F=\frac{1}{2\pi}\frac{\Delta W}{W} \qquad (3)$$

In this paper we want to make a study about internal friction of shape memory materials, especially alloys type Cu-Al-Ni, possible nice materials for bells or gongs or even musical strings. At this materials after deformation and material state can be observe three domains with very different values of internal friction:

1) In a state with martensite and austenite between M_f and M_s curve 3 and M+A domain where internal friction is extremely high and explained by reversible movement of interfaces between austenite and martensite [2].

2) In austenitic state curve 1 and domain A where internal friction is because of reversible movement of dislocations and punctiform defects IF have small values (appreciative 10^{-4});

3) In martensitic state, curve 2 and domain M the mechanical energy transformation in thermal energy happens because of reversible movement of interfaces between martensitic variants and IF have medium values (appreciative $5x10^{-3}$)

Internal friction depends of few factors like: temperature, deformation degree, material state, oscillation frequency. Internal friction dependence with temperature and with deformation degree is presented in figure 3. In region 1 the material is in martensitic state, in region 2 the material is between martensite and austenite with maximal values for amortization capacity and in region 3 the material is in austenitic state with a low internal friction Q_A [3]. The deformation degree influence on IF is presented in figure 4 b) with three curves 1-3 corresponding to those 3 different regions 1, 2 and 3.

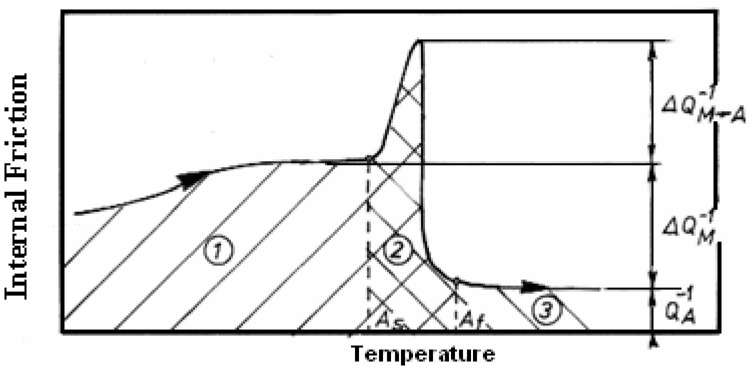
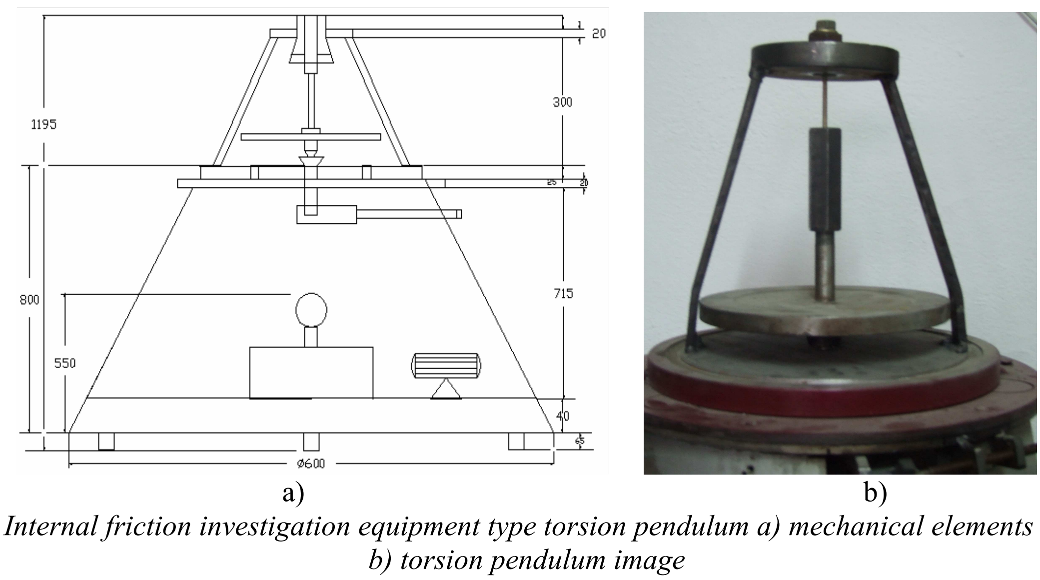


Fig. 2 Schematically diagrams of internal friction variation with temperature



a) b)

Fig. 3 Internal friction investigation equipment type torsion pendulum a) mechanical elements scheme b) torsion pendulum image

Most common measuring method of internal friction at metallic materials is utilization of a torsion pendulum to test and calculate alloys internal friction. Torsion pendulum based on physics vibration phenomena lows and is equipment like this one from figure 3:

Vibrations amortization origin is a characteristic of pseudo-elastic shape memory alloys because of step by step reducing of elastic modulus at reload and because of mechanical energy absorption by internal friction. Shape memory alloy based on Mn-Cu can reach values of internal friction of 200 times bigger than a steel or high purity aluminum or cooper [4].

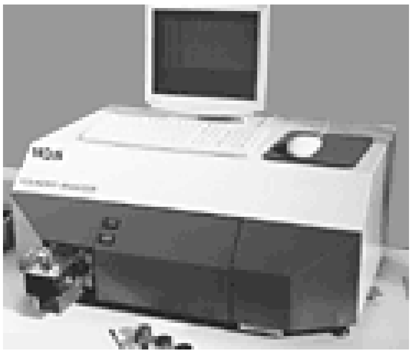
Experimental is proved that at high temperatures (>300 °C) exist an internal friction because of dislocations. Characteristic for this type of internal friction is exponential increase of IF with temperature and independence of amplitude:

$$Q^{-1}=Q_0^{-1}\exp(-U/kT) \tag{4}$$

Internal friction is proportioned with defects concentration and thermal activation has a important role in defects generation the internal friction dependence with temperature seems logical.

3. Experimental results

Tests was realize on a torsion pendulum, as has been stated above, the alloy tested have chemical composition $Cu_{73.8}Zn_{20.1}Al_{5.69}$ determined with a Foundry-Master 01j0013 spectrometer equipment.



WORLDWIDE ANALYTICAL SYSTEMS AG
WAS Sample Testing of different Qualities

aliaj 2

Buletin de analiza nr ......

	Cu	Zn	Pb	Sn	P	Mn	Fe	Ni
1	74.5	19.5	< 0.0050	0.0094	< 0.0030	0.0241	0.0165	< 0.0050
2	73.0	21.0	< 0.0050	0.0099	< 0.0030	0.0238	0.0235	< 0.0050
3	73.2	21.0	< 0.0050	0.0102	< 0.0030	0.0228	0.0308	< 0.0050
Ave	73.6	20.5	< 0.0050	0.0098	< 0.0030	0.0236	0.0236	< 0.0050

	Si	Mg	Cr	Al	S	As	Be	Ag
1	0.0762	< 0.0005	< 0.0010	5.77	< 0.0020	0.0062	< 0.0050	< 0.0020
2	0.0813	< 0.0005	< 0.0010	5.73	< 0.0020	0.0077	< 0.0050	0.0020
3	0.0898	< 0.0005	< 0.0010	5.62	< 0.0020	0.0076	< 0.0050	0.0024
Ave	0.0824	< 0.0005	< 0.0010	5.71	< 0.0020	0.0072	< 0.0050	0.0021

	Co
1	< 0.0150
2	< 0.0150
3	< 0.0150
Ave	< 0.0150

Fig. 4 Chemical analyze equipment type Foundry Master with a result table

Shape memory alloy capacity was tested with a Linseis L75HX dilatometer with satisfactory results thereby in first heating cycle to 350 ºC temperature using a heat rate of 10ºC/min the alloy present a contraction at heating, characteristic behavior of shape memory alloys for first heating cycle if this alloy present memory effect in smelt form.

In next three cycles the alloy comports like a normal brass.

Those four dilatation cycles which was our sample subjected are presented in figure 5

After smelting the material was homogenize at 800 ºC with maintaining time of 2 hours and cooled 24 hours with the oven and after that the alloy was hardened in salt water from a 800 ºC degree, the microstructures of alloy after this heat treatments are gthose presented in figure 6.

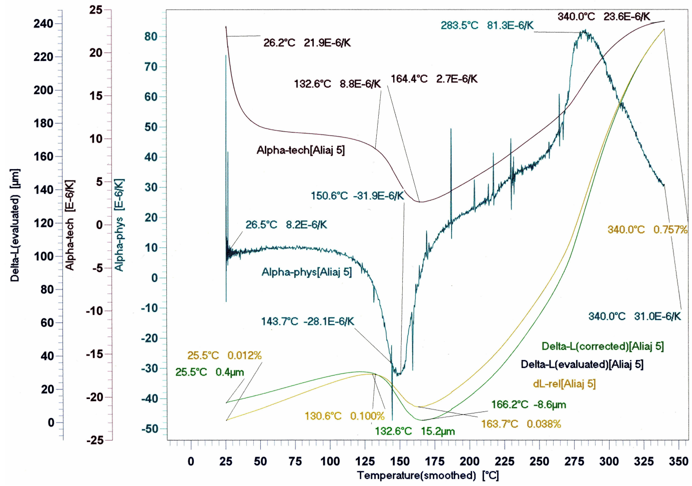
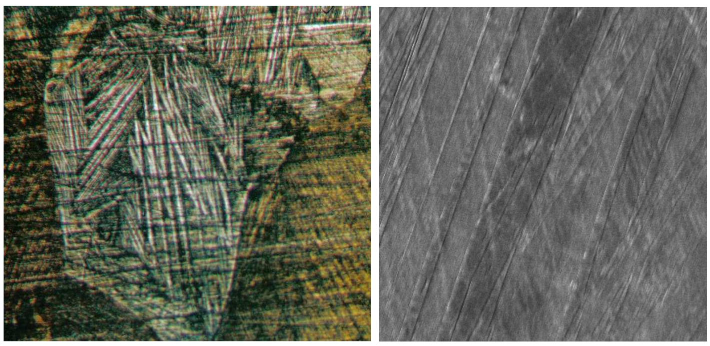


Fig. 5 Shape memory alloy $Cu_{73.8}Zn_{20.1}Al_{5.69}$ dilatometer investigation



a) b)

Fig. 6 Shape memory alloy $Cu_{74}Zn_{20}Al_{6}$ microstructure (attack with $FeCl_3$) a) homogenous state b) SEM micrograph 100x100 µm

After these investigations the material was mechanical prepared with alloy temperature controlled under water flow and prepared for catching system of torsion pendulum. Sample dimensions are presented in next image, figure 7:

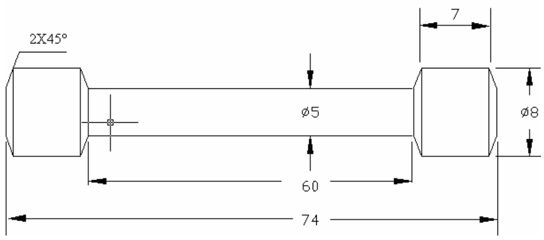


Fig. 7 Sample scheme for internal friction study with a torsion pendulum

Sample was tested in air with 1Hz frequency and heating rate 10 ºC/min for different temperatures so we can observe the differences between values of internal friction. The registered results graph is presented in figure 9.

4. Conclusions

A shape memory alloy was obtained by classical casting type CuZnAl, material with many practical applications, and was studied the variation phenomena of internal friction with temperature.

The temperature influence on IF values is present and show us the domain were this high amortization capacity of material can be useful in applications. As technical literature present, a god damping material must have an IF approximately of 0.2 value and we have for this SMA the value 0.08 which give to this class of materials chances for bigger values and to be used in amortization applications.

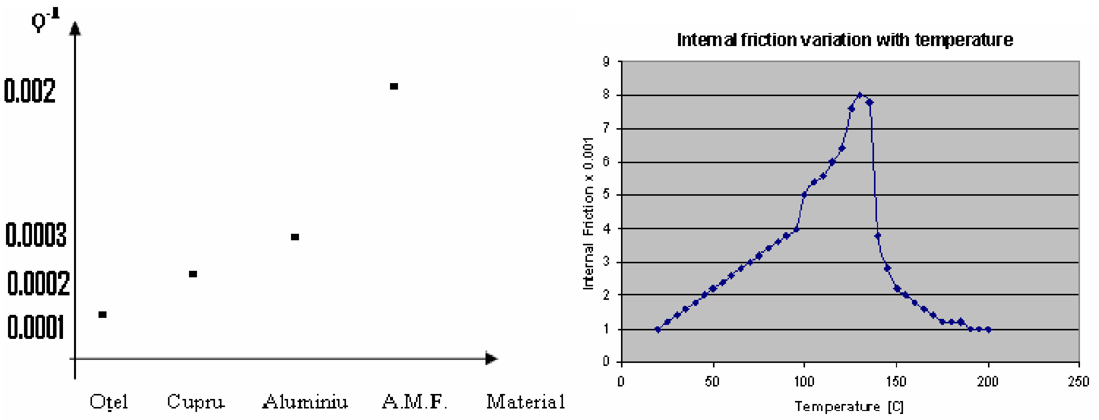


Fig. 8 a) Internal friction variation for different materials b) internal friction variation function of temperature for a based copper shape memory alloy.

Received November 11, 2008
Technical University "Gh. Asachi" Iaşi

REFERENCES

1. Aczel, O., Bozan, C., **Dizlocaţii şi frecarea internă la materialele metalice**, Ed. Facla, 1974
2. Gandhi, F., Wolons, D., **Characterization of the pseudoelastic damping behavior of shape memory alloy wires using complex modulus**, Smart Mater. Struct., 8, 1999, 49-56
3. De Jonghe, W., De Baptist, R., Delaey, L. and De Bonte, M., **Internal friction measurements on copper-zinc based martensite**, Shape Mem. Eff. All., (Perkins, J), Plenum Press, 1975, 451-466
4. Rodriguez, C. and Brown, L.C., **The mechanical properties of SME alloys**, Shape Mem. Eff. All., (Perkins, J., ed.), Plenum Press, 1975, 29-58

CAPACITATEA DE AMORTIZARE A MATERIALELOR METALICE

Rezumat: Frecarea internă mare înseamnă disiparea energiei sau proprietăţi bune de amortizare care influenţează mult rezonanţa materialelor metalice. Aceatsă lucrare prezintă un studio despre proprietăţile frecării interne (FI) a unor materiale metalice cu diverse utilizări şi aplicaţii ca materiale disipatoare. Studiul s-a realizat cu ajutorul unui pendul de torsiune iar materialele investigate sunt metalice şi cu diferite valori ale frecării interne. Pentru acest studio s-a ţinut cont şi de vârfurile diferite ale FI care apar pentru acelaşi material dar în domenii diferite cum ar fi austenitic sau martensitic.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

POINT OF VIEW REGARDING IMPLICATION OF NON-METALIC INCLUSIONS IN MODIFICATION PROCESS OF IRON TO OBTAIN NODULAR GRAPHITE

BY

VASILE COJOCARU-FILIPIUC

Abstract: An inoculating agent, like chemical element can be, in liquid iron, immediately after its introduction in the melt, as the following states: solid (for example, yttrium), liquid (for example, barium, but calcium, too) and gaseous (for example, thium, natrium and calcium, too). An inoculating agent chemical element can be in liquid iron, at inoculating temperature, as such or as simple or complex chemical compounds. This paper shows not all chemical compounds involved by modifier chemical elements can generate graphitization nucleus.

Keywords: inoculating, nodular graphite, graphitization mechanism.

1. Nature of the modifiers

According to [1], [2], [3] references, nodulizing inoculating chemical elements are following: Mg, Ce, Y, Ca, Li, Na and the chemical elements of rare earth group, respectively lanthanide and actinide. In general, inoculating chemical elements are following: Li and Be (second period), Na and Mg (third period), K, Ca and Sc (fourth period), Rb, Sr and Y (fifth period), Cs, Ba and La (sixth period), Fr, Ra and Ac (seventh period), Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu (lanthanide), respectively, Th, Pa and U (actinide).

If on agrees that inoculating elements are implicate for inoculating as chemical compounds, too, that's why it must agree that inoculating chemical elements have potentialities to use for inoculating as chemical compounds − metallic salt (CaF_2, $BaCl_2$, $CaCl_2$, $MgCl_2$ etc., but in combination with other chemical elements).

2. About inoculating mechanism

References [4] analyses nodular graphite germination theory on free surfaces − on the surfaces of the magnesium bubbles. The other hand, references [2], regarding at the same theme, explain about that on by the tending to thermodynamic equilibrium of chemical potentials of the chemical elements between two thermodynamic phases.

A magnesium bubble can be substituted by a modifier drop regarding to theinoculating mechanism.

Reference [5] shows, as nodular graphite germination support, non-metallic inclusions represented by MgO and MgS, but of small dimensions.

According to references [6], the non-metallic inclusions, that are crystallized in cubic system −MgS, Mg_3N_2, Mg_2Si and MgO −, involve germination and growth of the nodular graphite.

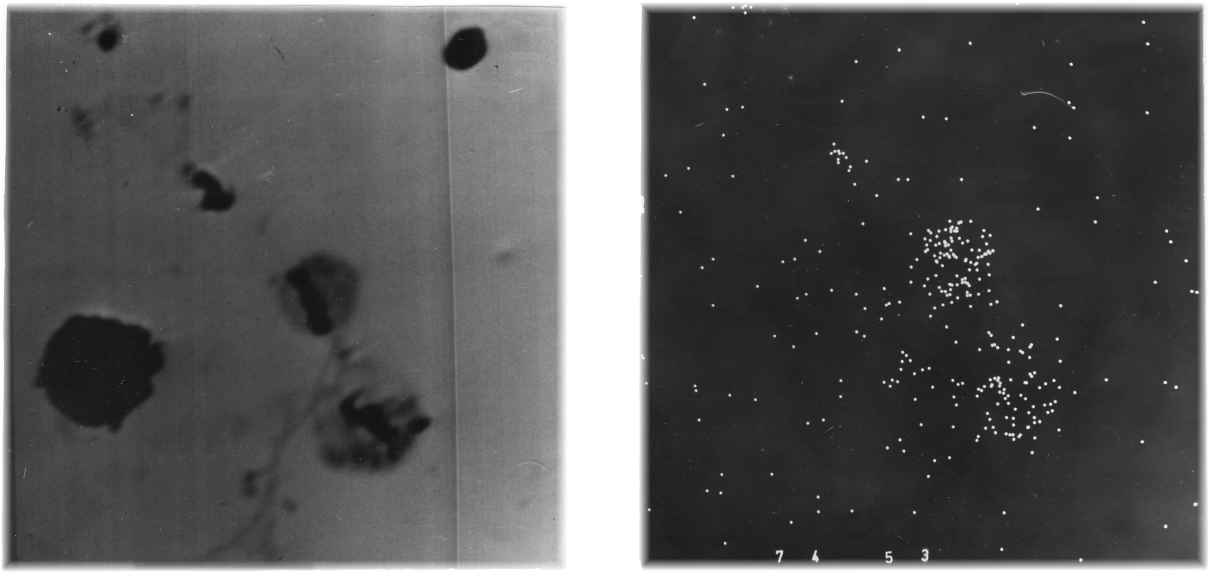
There are other theories which take into consideration implication of non-metallic inclusions for germination and growth of the nodular graphite.

Because there are graphite nodules which have non-metallic inclusions included in them, one guides to the conclusion that germination and growth mechanism of nodular graphite through the non-metallic inclusions is not known.

One estimates that modification phenomenon is one complex, a lot of factors being implicated.

Figure 1-a presents the composition image of a nodular graphite cast iron sample and figure 1-b presents the radiation image for the same nodular graphite cast iron sample − 1 sample.

The sample analyzed in figure 1 and another samples that were analyzed in this paper, were obtained by inoculating with FeSiCaMg that had 8% magnesium.



a) *b)*

Figure 1. Images obtained at the electron microsound for sample 1: a − composition image; b − radiation image.

The quantity of inoculating agent was of 1.7%.

Inoculating agent had two inoculating chemical elements − magnesium and calcium.

In figure 1-a one observes a graphite nodule placed in image quarter from left part, down, two non-metallic inclusions placed in image quarter from right part, down and non-metallic inclusions placed in image quarter from left part, up.

The radiation image from figure 1-b presents the distribution of the magnesium particles in all field of vision of the sample − in metallic matrix and in non-metallic inclusions, respectively in graphite inclusions and chemical compounds.

In figure 1 one observes the sporadic presence of the magnesium particles in graphite nodule and the presence of some agglomerations of the magnesium particles in the zone of those three non-metallic inclusions. So, those three non-metallic inclusions have as basis, magnesium chemical element. The magnesium particles are distributed uniform relative in the metallic matrix.

So, here you are the chemical compounds on the basis of magnesium which were not implicated in the modification process. Well, not all chemical compounds on the basis of magnesium constitute support for germination and growth of graphite as nodules.

Figure 1 shows that non-metallic inclusions have the size order of the dimensions as that one of the graphite nodule placed next to them.

One estimates that there is a critical size of the chemical compounds on the basis inoculating chemical elements. For values bigger than those critical sizes, those chemical compounds can not constitute support for the germination and growth of nodular graphite.

After the pouring of the inoculating iron in the mould, rate of cooling of the melt is significant, this situation involving the stopping of the carbon diffusion process, obtaining graphite nodules of small dimensions or the diffusion process of carbon becoming of small intensity (it's not possible to obtain nodular graphite at temperatures assigned to modification). It is established that the graphite nodules are constituted during cooling, in temperatures period of 1350…1320^{0}C.

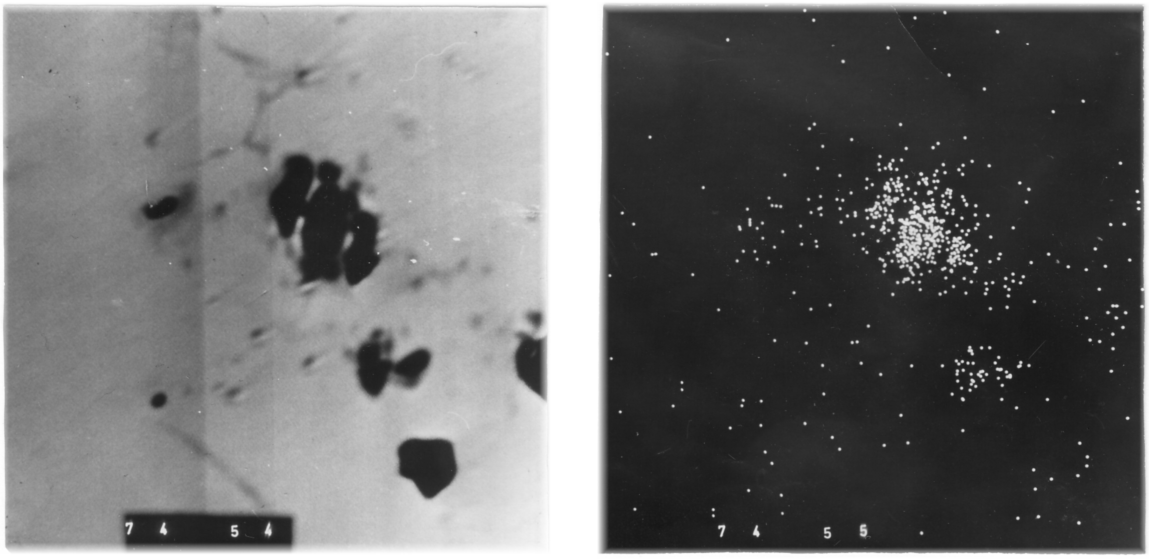
Because the size of the chemical compounds on the basis of magnesium has the same size order as that one of the graphite nodules, the obtaining of a graphite nodule on so big support would necessitate a big quantity of carbon which to crystallize as graphite. In the same time, it would necessitate a big time for the diffusion of the carbon particles. In the conditions of the cooling in the mould it would not be possible to obtain the graphite nodules on the so big non-metallic inclusions.

In figure 2, for sample 2, one observes in composition image a) a graphite nodule place in the image quarter of down, in right part. In this zone there is a half of graphite nodule, too. In the same composition image there is a non-metallic inclusion that has the dimensions bigger then that one of graphite nodule −of three time bigger. On that composition image there are the non-metallic inclusions whose size is less than that one of the graphite nodule (a non-metallic inclusion is placed in left part of the big non-metallic inclusion and another one is placed above of half of graphite nodule). The non-metallic inclusion placed above the graphite nodule has the size relatively same as that one of the graphite nodule. Those four non-metallic inclusions are on the basis of magnesium, this situation resulting from the radiation image presented in figure 2-b.

Even if non-metallic inclusions on the basis of magnesium had dimensions less than those ones of the graphite nodule − about 1/3 from the nodules size − they did not constitute heterogeneous support for the germination and growth of the nodular graphite.

One estimates that the critical size of a chemical compound to have the quality of crystallizing support of the nodular graphite, is more less than the size of a graphite nodule (for example, the maximum size of a graphite nodule is 10 μm).

To explain the nodular graphite germination it must take into consideration the law of the tending to the thermodynamic equilibrium of the chemical potentials of the chemical elements between two thermodynamic phases, those ones being in direct touch.



a) b)

Figure 2. Images obtained at the electron microsound for sample 2: a −composition image; b −radiation image.

Indifferently of size, a non-metallic inclusion must perform one's functions of every modifier to constitute support for germinating and growthing of nodular graphite, that is the following conditiond, [2]:

− do not solve onselves in liquid iron or to have a small solving capacity in that one;

− to decrease the carbon solving in liquid iron;

− to constitute a thermodynamic phase in the smelt.

The degree of purity of iron that is inoculated, must be big, otherwise, the diffusion process of carbon is significant braked or is inhibited.

If the non-metallic inclusions would be in liquid state, because the component particles would be in a relative chaotic agitation, the nodular graphite germination and growth mechanism would be similar to that one which occur in the case of the inoculating agents which are in gaseous or liquid state at the inoculating temperature of iron.

If the non-metallic inclusions are in the solid state, the attraction forces among the component particles that can be stronger or weaker.

If the non-metallic inclusions arised endothermicly, during decreasing of the temperature, their stability increases. If the temperature would be constant, the non-metallic inclusions would solve in the liquid metallic matrix.

To constitute a support for germinating and growthing of the nodular graphite, it must that at the non-metallic inclusion-metallic matrix interface, the thermodynamic activity of carbon to have 1 value, this one being a obligatory condition for arising of the graphite nucleus. Normally, this fact occurs at the eutectic temperature, where the carbon thermodynamic activity reach the 1 value. In addition, it must be a justification for diffusing of the carbon particles to the non-metallic inclusions.

The justification of that one is the big difference of the carbon thermodynamic activity between the metallic matrix and the chemical compound. This one would mark that the non-metallic inclusion must do not have carbon − do not be carbonate, carbide etc.

The mark of interrogation which remains is the critic size of the non-metallic inclusion which to do possibly the growthing of the nodular graphite around about of this one − of course, it is about of a values interval.

The big degree of purity of iron involves a bigger coefficient of diffusion of the carbon particles. In the case of a technical iron, in microvolums where the degree of purity is big, only, it is possible that non-metallic inclusions to constitute support for germinating and growthing of the nodular graphite.

The non-metallic inclusions must have a geometry as compact as possible − as spheroidal as possible, otherwise, unobtaining graphite with a compact geometry − spheroidal one.

The non-metallic inclusion-graphite interphase tension must be small. Taking into consideration that the graphite-air interphase tension is constant in the certain case − for example, for a temperature − there is the conclusion that not any a non-metallic inclusion could constitute a support for germinating and growthing of the nodular graphite. Well, non-metallic inclusions which involve a non-metallic inclusion-graphite interface tension under a critical value, can constitute a support for germinating and growthing of the nodular graphite. Taking into consideration the [7] reference, moistening angle non-metallic inclusion-graphite must be as small as possible and non-metallic inclusion-graphite interphase tension must be as small possible, too.

After constituting of graphite nodules on non-metallic inclusions supports, these become unstable from thermodynamic point of view, because a big difference between the thermodynamic activity of carbon from graphite and the thermodynamic activity of carbon from the metallic matrix, appears − lack of balance between the chemical potential of carbon from nodular graphite and the chemical potential of carbon from metallic matrix (both phase are thermodynamic) appears. Result of that lack of balance is the diffusion of graphite from graphite nodules to the metallic matrix, especially that the conection forces between two graphite layers from graphite crystal lattice, are weak. That's why the pouring of the inoculated iron is indispensable to do immediately after iron inoculating, otherwise, inoculating effect being annulled.

3. Conclusions

3.1. There is a critical size of the non-metallic inclusions to be possible the growthing of the nodular graphite round about of them.

3.2. the condition 3.1 must be together with the following characteristics:

− big degree of purity of iron, otherwise, iron inoculating itself on the basis of non-metallic inclusions in microvolums which have a big degree of purity, only;

− the non-metallic inclusions do not solve in liquid iron;

− the non-metallic inclusions must constitute a thermodynamic phases;

− the non-metallic inclusions must involve the decreasing of the carbon solubility in liquid iron;

− the non-metallic inclusions must increase the carbon thermodynamic activity in liquid iron;

− the non-metallic inclusions must be spheroidal, otherwise the geometry of obtained graphite will not be nodular;

− the non-metallic inclusion-graphite interphase tension must be small.

Received November 22, 2008

Technical University "Gh. Asachi" Iaşi

REFERENCES

1. Ripoşan, I. and Sofroni, L. **Fonta cu grafit vermicular**. Bucureşti. Editura "Tehnică". 1984;
2. Cojocaru-Filipiuc, V. **Nodulizarea grafitului în fonte − aspecte teoretice**. Iaşi. Editura „**Politehnium**". 2007;
3. Sofroni, L., Ştefănescu, D.M. and Vincenz, C. **Fonta cu grafit nodular**. Bucureşti. Editura „Tehnică".1978;
4. Itofuji, H. *Proposal of Site Theory.* ASF Transaction. 1996.ref.96…131. p.79…87. Translation by Sofroni, L. **Cu privire la teoria formării grafitului nodular**. Bucureşti. „Revista de Turnătorie". 2004. Nr. 5, 6. p. 4…14.
5. Östberg, G. **Perspectives on research on the formation of nodular graphite in cast iron**. Material Design. Vol. 27. Issue 10. 2006. p.1007−1015;
6. Sofroni, L. and Ştefănescu, D.M.**Fonte modificate cu proprietăți speciale**.Bucureşti. Editura "Tehnică". 1971;
7. Cojocaru-Filipiuc, V. **Punct de vedere privind creşterea grafitului nodular**. Bucureşti. „Revista de Turnătorie" nr. 34/2005. p. 2…7.

PUNCT DE VEDERE PRIVIND IMPLICAREA INCLUZIUNILOR NEMETALICE IN PROCESUL DE MODIFICARE A FONTEI IN VEDEREA OBTINERII GRAFITULUI NODULAR

Rezumat: Un modificator se poate afla în fonta lichida, imediat dupa introducerea in baia metalica, in starile de agregare solida (de exemplu, ytriul), lichida (de exemplu, ceriul, bariul dar si calciul) si gazoasa (de exemplu, magneziul, litiul, natriul dar si calciul). Un element chimic modificator se poate afla in fonta lichida, la temperatura de modificare, ca atare sau sub forma de compusi chimici simpli sau complecsi. Prezenta lucrare demonstreaza ca nu toti compusii chimici la care dau nastere elementele chimice modificatoare pot sa genereze germeni de grafitizare.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

ANALYSIS OF THE GRAPHITE DEGENERATION IN THE CASE OF IRON INOCULATING IN THE LADLE, DURING OF THE IRON MAINTAIN IN THE LIQUID STATE, AFTER INOCULATING

BY

VASILE COJOCARU-FILIPIUC

Abstract: The paper shoes a original theoretical analysis of the uninoculating phenomenon of the iron, based on the thermodynamic equilibrium between the metallic matrix and the graphite nodules.
One research the degree of degeneration of the graphite nodulizing, in the circumstances of a period elapsed from the inoculating of the maximum 19 minutes, drawing a conclusion that in that time period was not perceived a significant degeneration of the nodular graphite geometry.

Keywords: nodular graphite, uninoculating, thermodynamic equilibrium.

1 General considerations about uninoculating

After inoculating agent adding in melt, the ideal would be that iron to begin to solidify. “To be next to the ideal” is when the inoculating is done in the mould.

If the inoculating is done in the ladle, in practice, a lot of accidents can occur, for example, the following:

− the inoculating technology, as such − for example, the inoculating occurs during the evacuating from the furnace;
− accidental deteriorating of the crane;
− retarding of moulds preparing for pouring;
− shifting of the ladle on the big distances to pouring platform;
− big capacity of the ladle according to the pouring of the little castings;
− taking over of the inoculated liquid iron from a ladle of the big capacity by ladles of the small capacities which are assigned to the pouring on the conveyer;
− apparition of the perturbations at moulds pouring,
− temporary break of the electrical energy delivering;
− apparition of the some problems of the technical staff etc.

The references [1], [2], [3], [4] present the inoculating phenomenon, indicating as cause the desorption phenomenon of the inoculating chemical elements from the surface of the graphite nodules and the eliminating of the magnesium bubbles, [5] etc.

It is explained, by diverse methods, that the graphite nodules are constitute during of the cooling of the liquid iron, after the adding of the inoculating agent in smelt, between the temperatures of 1350 and 1320^{0}C, [6].

The mechanism of the graphite nodules constituting is not known in totality, being available hypothesis and hypothesis verified experimentally.

In any way, one can accept the growth of the nodular graphite in a liquid metallic matrix, during of its cooling, the certificating being the flotation of the graphite nodules or, for example, the finding of the graphite nodules in a metallic matrix submitted to a hardening from the liquid state, from a temperature less than 1320^0C.

Certainly, the constituting of the graphite nodules supposed the diffusion of the carbon particles through the liquid solution to the graphite nucleus of the nodular graphite. So, the conclusion is that the uninoculating consists in the diffusion of the carbon particles from the graphite nodules in the liquid solution. It must not to take no care of the risk that graphite nodules to deform during the eutectic transformation, especially because of some liquid channels perceptibley experimentally in the graphite nodules and because an bad chemical composition of iron.

The constituting of the graphite nodules between the temperatures of 1350 and 1320^0C, in any way, was not based on Fick diffusion laws because the carbon particles diffused from a thermodynamic phase in which the carbon proportion was less − liquid solution − to a thermodynamic phase in which the carbon proportion was bigger − the graphite nodule during the substituting.

Certainly, the cause of the particles diffusion from the liquid solution to the graphite nucleus is the tending to the thermodynamic equilibrium between two thermodynamic phases, equilibrium which consists in equalization of the chemical elements chemical potentials between those two thermodynamic phases − metallic matrix (the liquid solution) and the graphite nuclei which, in any way, have a material connection with a thermodynamic phase (bubbles, drops of the inoculating agents, chemical compounds created by the inoculating chemical elements, in the case of an inoculating of a technical iron, for example).

After the constituting of the graphite nodules in a temperature interval very small −about 30^0C, respectively, during the cooling of the liquid iron from 1350^0C temperature to the 1320^0C temperature − it appears a thermodynamic lack of balance between the liquid solution and the graphite nodules regarding the size of the carbon chemical potential. Concretely, if in the graphite nodules the carbon concentration is of about 100%, in the liquid solution from round about the graphite nodules the carbon concentration is more less −for example in a technical iron inoculated, of 3%.

It would have that the diffusion phenomenon of the carbon particles to be reversible, that is, if the graphite nodules were constituted during the normal cooling, during a temperature interval of 30^0C -1350^0C…1320^0C −, too, in a temperature interval to occur the carbon particles diffusion from the graphite nodules to the liquid solution.

The carbon diffusion coefficient depends significantly of temperature, degree of chaotic agitation of the carbon particles from liquid solution, density of clusters from the liquid solution etc., so, at the temperatures less then value of 1320^0C, carbon diffusion coefficient is decreased significant. As a result, the carbon particles diffusion from the graphite nodules to the liquid solution will be in a time bigger than that one from the metallic matrix to the graphite nodules, but at bigger temperature (1350…1320^0C).

Theoretically, the "dissolution" process of the graphite nodules begins immediately after their constituting.

If the graphite nodules, in normal cooling conditions, were constituted in a time of maximum a minute, in the temperatures interval of 1350…1320^{0}C, the "dissolution" phenomenon of the graphite nodules in the liquid solution, at the temperatures less than 1320^{0}C, can last more then a minute, in the practice conditions, the "dissolution" time of the graphite nodules being more than 15 minutes. After the graphite nodules dissolution in the liquid solution, the liquid iron follows the normal way of solidification − having the normal conditions of cooling rate, the solidification is as grey cast iron with lamellar graphite.

In practice, the inoculated iron must be poured immediately after the inoculating to the dissolution process of the graphite nodules to be insignificant during the pouring in the mould.

2. Experiments

To analyse if the graphite nodules are degenerated from the nodular geometry, in the conditions of pouring of iron of industrial importance, samples were drawn after different time periods from the inoculating. In table 1 it is presented the experiment programming , [10], [11].

Table 1.The experiment programming for the graphite degeneration study.

Number of parallel determinations	Level of the y* factor (drawing at the elapsed time, in min)					
	1(3)	2(10)	3(11)	4(15)	5(17)	6=m(19)
1	100	100	100	100	100	100
2	100	100	99	100	100	100
3=n	100	100	100	100	98	100
Average	100	100	99.67	100	99.32	100
Dispersion on columns	$s_1^2 = 0$	$s_2^2 = 0$	$s_3^2 = -0.41$	$s_4^2 = 0$	$s_5^2 = 3.54$	$s_6^2 = 0$

*: y is the nodular graphite proportion from the graphite in all.

Figure 1. The ladle with two modifier slots and two plungers.

Iron was inoculated in a ladle with two modifier slots and two plungers, [7] − figure 1. The inoculating was done with master alloy FeSiCaMg, with 8% magnesium, the quantity of master alloy being of 1.7%. The final inoculating was done with FeSi75, the silicium content being of about 72% and the size of granulation being of 3…10 mm. The final inoculating was done in the ladles of the 50 kg capacity.

In the table 2 is presented the chemical composition of the samples from 2 table.
The secondary structure for some samples, without pickling, is presented in figure 2 (a) − without pickling; b) − with pickling).

Table 2. The chemical composition of the samples from table 1.

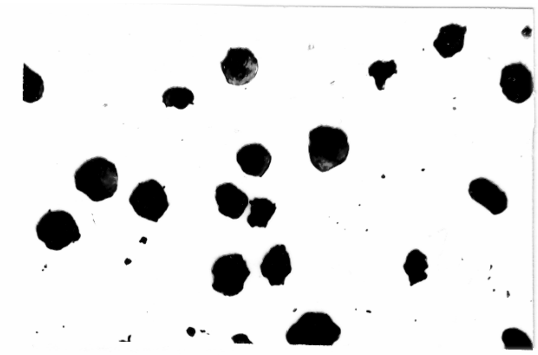
Sample number	Chemical composition, in %								
	C	Mn	Si	P	S	Cr	Ni	Mo	Mg
1/1	3,32	0.88	1.85	0.08	0.01	0.10	0.02	0.02	0.009
2/1	3.30	0.90	2.18	0.08	0.01	0.11	0.02	0.02	0.018
3/1	3.34	0.90	2.15	0.08	0.01	0.11	0.02	0.02	0.020
4/1	3.22	0.90	2.17	0.08	0.01	0.10	0.02	0.02	0.019
5/1	3.31	0.92	2.19	0.08	0.01	*abs	abs	abs	0.017
6/1	3.30	0.94	2.19	0.08	0.01	abs	abs	abs	0.017
1/2	3.31	0.94	2.12	0.08	0.01	0.10	0.02	0.02	0.020
2/2	3.31	0.94	2.12	0.08	0.01	0.10	0.02	0.02	0.017
3/2	3.33	0.95	2.12	0.08	0.01	0.10	0.02	0.02	0.017
4/2	3.32	0.94	2.13	0.08	0.01	0.10	0.02	0.02	0.020
5/2	3.34	0.96	2.12	0.08	0.01	0.10	0.02	0.02	0.020
6/2	3.34	0.96	2.12	0.08	0.01	0.11	0.02	0.02	0.021
1/3	3.31	0.98	2.15	0.07	0.01	0.11	0.02	0.02	0.018
2/3	3.30	0.96	2.19	0.07	0.01	0.11	0.02	0.02	0.019
3/3	3.30	0.97	2.12	0.07	0.01	0.11	0.02	0.02	0.019
4/3	3.32	0.96	2.19	0.07	0.01	0.11	0.02	0.02	0.019
5/3	3.32	0.96	2.19	0.07	0.01	0.11	0.02	0.02	0.020
6/3	3.30	0.96	2.19	0.07	0.01	0.11	0.02	0.02	0.021

* = absence

All those 18 samples drawed had the size of graphite nodules diameter of 40…60 µm, the total surface of the graphite nodules was of 3…5% and the number of graphite nodules on surface unit had value of about 50 nodules/mm^2.

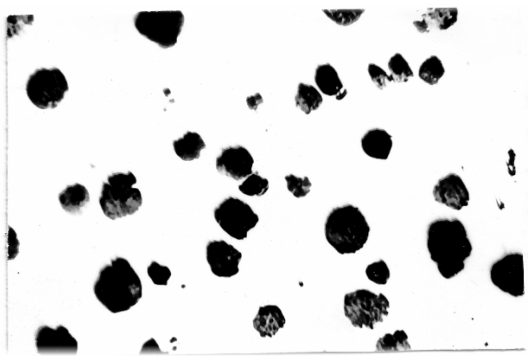
The magnesium assimilating efficiency had value of about 15%.

The analysis of the structures from figure 2, shows the absence of the significant degeneration of the graphite geometry from the nodular geometry, after 19 min from inoculating.

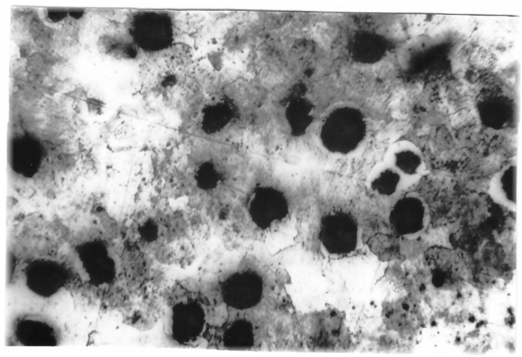


sample 1/1 – a)

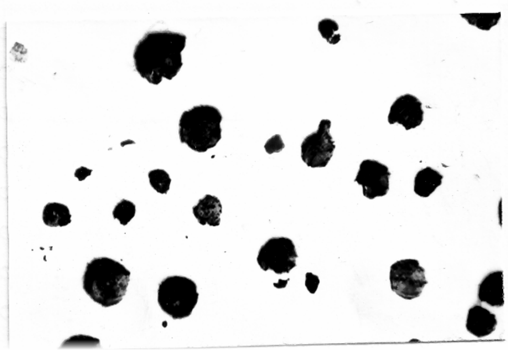
sample 1/1 – b)



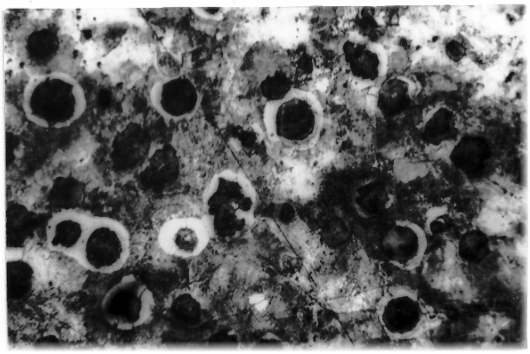
sample 2/2 – a)



sample 2/2 – b)

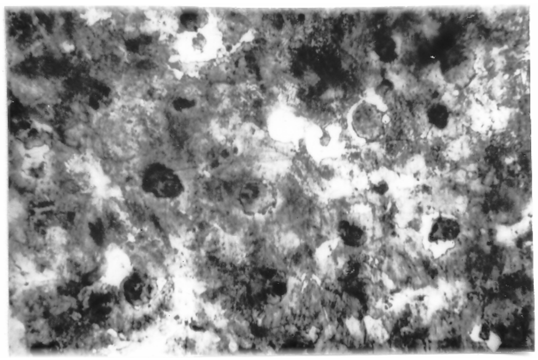


sample 3/1 − a)



sample 3/1 − b)

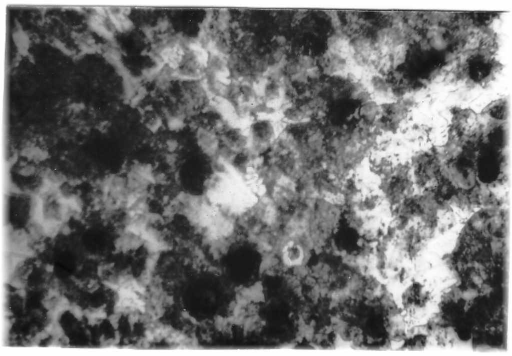
sample 4/3 − a)



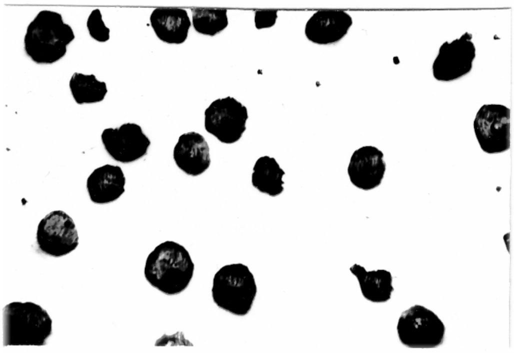
sample 4/3 − b)

Figure 2. Secondary of some samples, without pickling; a) − and with pickling − b) − to be continued

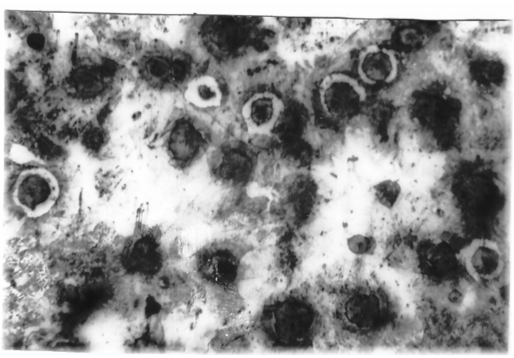
sample 5/1 − a)



sample 5/1 − b)



sample 6/2 − a)



sample 6/2 − b)

Figure 3. Secondary of some samples, without pickling − a) − and with pickling − b) − continued

3. The final conclusion

If iron is inoculated in the ladle presented in figure 1, in the case of the inoculating of about 500 kg iron, after 19 min from the inoculating, the nodular graphite is not significant degenerated from the nodular geometry.

Received November 14, 2008 *Technical University "Gh. Asachi" Iaşi*

REFERENCES

1. Sofroni, L., **Elaborarea şi turnarea aliajelor,** Bucureşti, Editura "Didactică şi Pedagogică şi Pedagogică", 1975;
2. Sofroni, L., Riposan, I., Brabie, V. and Chişamera, M., **Turnarea fontei**, Bucureşti, Editura "Didactică şi Pedagogică şi Pedagogică", 1985;
3. Sofroni, L., and Ştefănescu, D.M., **Fonte modificate cu proprietăți superioare**, Bucureşti, Editura „Tehnică", 1971;
4. Sofroni, L., Ştefănescu, D.M. and Vicenz, C., **Fonta cu grafit nodular**, Bucureşti, Editura „Tehnică", 1978;
5. Sofroni, L., **Cu privire la teoria formării grafitului nodular**, Bucureşti, „Revista de Turnătorie", 2004, Nr. 5, 6/p. 4-14;
6. Cojocaru-Filipiuc, V., **Nodulizarea grafitului în fonte − aspecte teoretice**, Iaşi, Editura „Politehnium", 2007;
7. Cojocaru, V., **Contribuții privind îmbunătățirea tehnologiei de obținere a fontei modificate cu grafit nodular**, Iaşi, Institutul Politehnic, Teză de doctorat, 1988;
8. Vlădescu, M. and Popescu, T., **Metode matematice pentru modelarea proceselor de elaborare a fontei şi oțelului**, Bucureşti, Editura „Tehnică",1975;
9. Taloi, D. **Optimizarea proceselor tehnologice**, Bucureşti, Editura „Academiei R.S.R." 1987;
10. Mihail, R., **Introducere în strategia experimentării, cu aplicații din tehnologia chimică**, Bucureşti, Editura „Ştiințifică şi Enciclopedică", 1976;
11. Coman, Gh. And Grădinaru, N., **Studii şi cercetări privind modelarea şi optimizarea sistemelor tehnologice în construcția de maşini**, Iaşi, Institutul Politehnic din Iaşi, 1980.

ANALIZA DEGENERARII GRAFITULUI IN CAZUL MODIFICARII FONTEI IN OALA DE TURNARE, IN TIMPUL MENTINERII FONTEI IN STARE LICHIDA DUPA MODIFICARE

Rezumat: Lucrarea prezinta o analiza teoretica originala a fenomenului de demodificare a fontei bazata pe echilibrul termodinamic dintre matricea metalica si nodulele de grafit.
Se cerceteaza gradul de degenerare a nodulizarii grafitului in circumstantele unei durate scurse de la modificare de maximum 19 minute concluzionându-se ca in respectiva perioada nu s-a sesizat o degenerare semnificativa a geometriei grafitului nodular.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

IMPACT THOUGNESS OF THE WELDED DEPOSITS ON GRAY CAST IRON - A COMPLEX FUNCTION

BY

DIANA GHEORGHIU*, OVIDIU CALANCIA*, DAN RIDICHE**

Abstract: The following article demonstrates that the impact thoughness of the cast iron welded deposits depends both on the work out mode of the base material, electrode type and electrode coat. The present experimental work confirm the nonferrous consumable quality.

Keywords: impact energy; arc furnace, induction furnace, electrode type.

1. Introduction

Grey cast iron welding process is a difficult technical one, beginning with add material selection. Even with similar chemical composition, properties and the structure of the base material can vary consistently. Grey cast iron structure makes this alloy a fragile one. It fracture is a brittle one. Welding process makes it even brittle. An adequate selection of the electrode and / or electrode coat composition can ensure an impact thougness of the weld similar to that of the base material.

All over the world standards recommend for welding cast iron six add material groups. Those with nonferrous content ensure best welding qualities, including thougness in many applications. The nickel or nickel copper based electrodes high price, the great interest for nickel in prior technical branches as well as some limits of the electrodes in practice keep awake the interest for replacing or at least reducing nickel electrodes consumption. Researches on new electrodes, wire and coat, for cast iron welding are developed in France, China, USA; there are sustained by foundry and welding professional associations, /1/, /2/.

The present paper presents the results of the tests regarding the complex influence of the base material / wire / coat composition on the impact thougness.

2. Materials and welding parameters

The selected cast iron is grey cast iron $Fc\,250$ grade; the chemical composition of the base materials is available in Table 1. In order to compare the inheritance influence on the weld deposit properties, the samples were machined from two different materials. Half were worked out into an arc furnace and half into an inductance one. There are little differences between the chemical composition of the materials as they are coming from induction furnace or arc furnace.

Table 1

Cast iron	Chemical composition, %												
	C	Si	Mn	P	S	Cr	Ni	Al	Cu	V	Ti	Sn	Co
Induction furnace	3,4	1,9	0,84	0,11	0,06	0,09	0,04	0,007	0,21	0,01			
Arc furnace	3,34	2,56	0,77		0,07	0,043	0,033	0,007	0,156	0,03	0,009	0,012	0,001

For better comparison the equivalent carbon has been calculated, with the following formulas:

$\mathrm{C.E.} = \mathrm{C_t} + 0{,}3(\mathrm{Si} + \mathrm{P}) - 0{,}03\mathrm{Mn} + 0{,}4\mathrm{S}$	/1/
$C.E. = C + 0{,}3Si + 0{,}33P + 0{,}45S - 0{,}28Mn + Mo + Cr - 0{,}02Ni - 0{,}01Cu$	/2/
$\mathrm{C.E.} = \%\mathrm{C} + 0{,}3(\%\mathrm{Si} + \%\mathrm{P})$	/3/

The calculated carbon equivalent value as well as the tensile strength of the materials is presented in Table 2.

Table 2

Cast iron grade Fc250	Strenght , R_r [N/mm^2]	Carbon echivalent, C.E., calculated with:		
		/1/	/2/	/3/
Fc 250, induction furnace	279	4,0018	3,8852	4,003
Fc 250, arc furnace	284	4,1129	3,96468	4,108

Microstructural analysis, figure 1, reveals a pearlitic matrix, few steadite and graphite flakes.

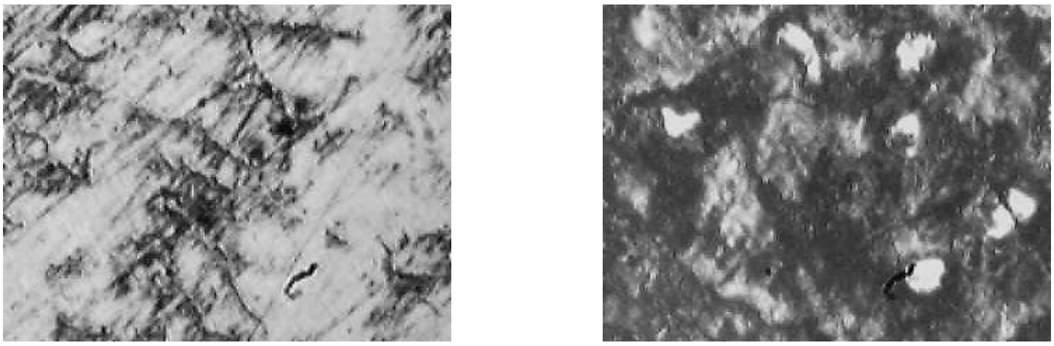


Figure 1. Base material microstructure: a. unetched; b. etched, nital, x 200.

As add material the electrode grades presented in Table 3 were used. The electrode grades ensure the adequate experimental conditions: the metallic core is the same - the chemical composition in Table 4; the ratio wire diameter versus electrode diameter is the same. Also nonferrous electrodes, NiFe and NiCu were used.

Table 3

Commercial name	Standard symbol	Minimum tensile strength daN/mm^2	Core type	Current type
E 44 T	E 43.2.R.2.2	43	acid	c.c., c.a.
E 7016	E 51.3.B.2.3.H	51	bazic	c.c., c.a.

Tabel 4

Wire grade	Chemical composition, %							
	Fe	C	Mn	Si	Ni	Cr	S, max.	P, max.
S 10	98	0,1	0,5	0,03	0,25	0,18	0,03	0,03

Electrode diameter used in the presented experiment is 2,5 mm. The welding parameters were: straight current, direct polarity, welding intensity 100 A.

Three specimens were carried out for every electrode type and base material.

3. Experimental research

From the selected furnaces charge cylindrical samples, no notch were fabricated. Their dimensions were: 17 mm diameter and 60 mm length.

The impact thougness tests were conducted on a Charpy pendulum with increasing impact energy. The selected initial energy range was: 16, 26, 38, and 52 J. The following results include the initial energy for the broken samples.

The following charts, figures 2, 3 and 4 resume the experimental results.

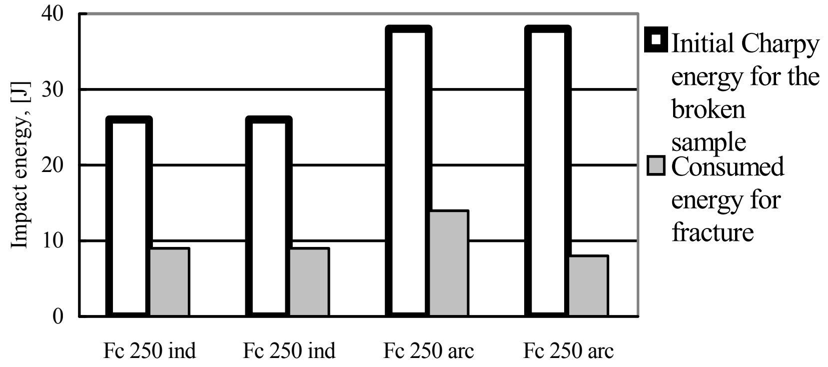


Figure 2. Representation of the impact energy values for some unwelded broken samples.

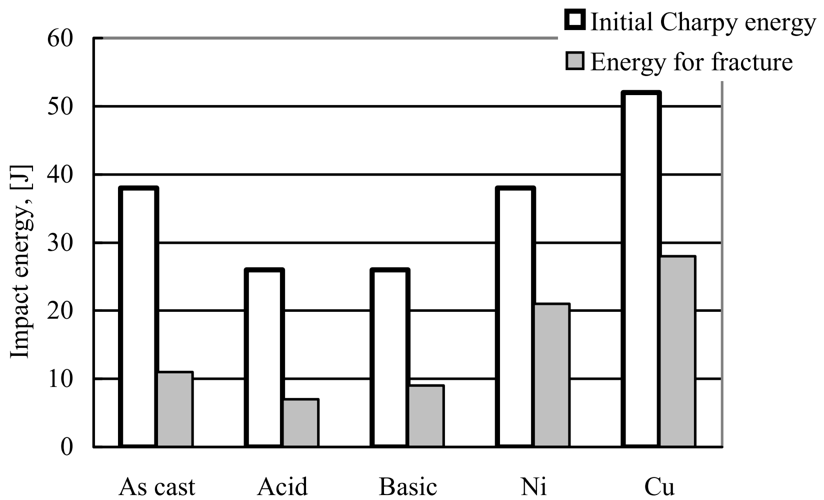


Figure 3. Impact fracture energy values for worked in arc furnace samples, all electrode types.

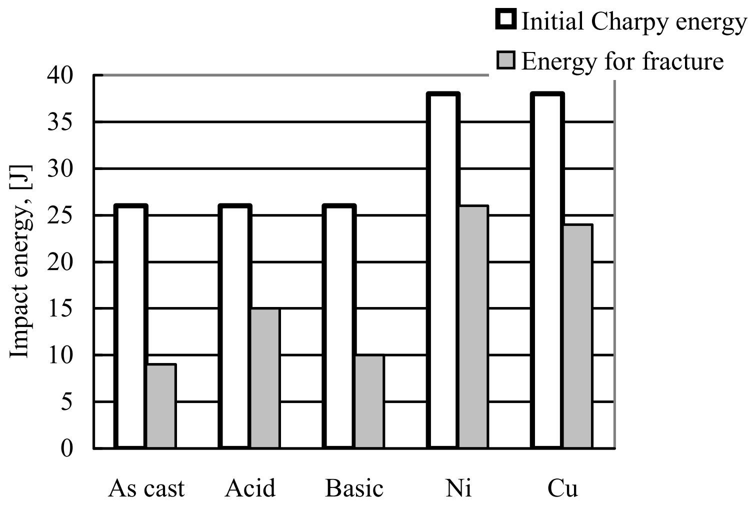


Figure. 4. Impact fracture energy values for worked in induction furnace samples, all electrode types.

In unwelded conditions the gray cast iron coming from induction furnace demonstrates regular properties. The arc furnace gray cast iron properties are less uniform, but sometimes higher, figure 2.

In welded conditions, arc worked out base material demonstrates the same irregularity for the observed characteristic, figure 3. The base material induction furnace charge in weld conditions displays better impact properties.

Best results are observed for welds made with nonferrous electrodes. Impact energy values are higher than that in unwelded conditions. The recorded values for the impact energy were taken when the samples were broken. No record were made for crack development into base material samples, with no fracture.

4. Conclusions

As result of the presented work, at this moment it can be assumed that: the work out conditions influences the impact properties of the cast iron; breaking impact energy is higher for nonferrous electrodes, as a consequence of their high plasticity.

Received November 18, 2008

**Technical University "Gh. Asachi" Iaşi*
***Secondary School "Unirea" Paşcani*

REFERENCES

1. Capitain, F., **Deux solutions innovatives pour le soudage a l'arc et electrodes enrobees des fontes GS**, Doc. IIS IX – 1855 – 96.
2. Zhou, Z. F., **New advances for cast iron welding in China in the last decade**, IIW Doc. II –1231 –94.

TENACITATEA DEPUNERILOR SUDATE PE FONTA CENUSIE – O FUNCTIE COMPLEXA

Rezumat: Articolul demonstreaza ca tenacitatea depozitelor sudate pe fonte cenusii depinde atat de modul de elaborare al materialului de baza, tipul de sarma de electrod si invelisul de elctrod. Experimentul confirma calitatea electrozilor din aliaj neferos.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

DEPENDENCE OF PLASTIC ULTIMATE STRAIN FROM A FRICTION AT END FACES AT AXISYMMETRIC COMPRESSION

BY

VOLODYMYR MYKHALEVYCH, YURIY DOBRANUK, VOLODYMYR KRAEVSKIY and OLEKSIY MYKHALEVYCH

Abstract: The axisymmetric compression of cylindrical blank between plane-parallel slabs is considered. The procedure, concrete mathematical model and the program of computing of the mode of deformation and the plastic ultimate strain on a free lateral surface of cylindrical blank are developed.

Keywords: axisymmetric compression, plastic ultimate strain, tensor model damage

1. Introduction

The axisymmetric compression of cylindrical blank is not only widespread technological operation, but also one of ways of laboratory researches for definition of the major technological properties of materials. As is known 0 at compression of cylindrical blanks of a low-plastic materials on a lateral surface flaws are generated. The compression extent at which there are flaws depends on barrel distortion intensity of a lateral surface. In turn the barrel distortion intensity is defined by magnitude of a friction at end faces of blank 0. Procedure of definition of the mode of deformation of a material on a cylindrical blank's free surface at its plastic axisymmetric compression are developed in 0. In this paper the procedure of definition of the plastic ultimate strain depending on barrel distortion intensity is developed.

2. Major part

On a lateral surface of the cylindrical blank in medial over of a altitude area the mesh is marked. The mesh is marked by a typographical expedient 0 or by means of the diamond imprints executed on Vickers hardness tester 0. By measured results of the distorted dividing mesh at the intermediate stages of the straining the dependence between axial strain ε_z and the hoop strain ε_φ is fixed

$$\varepsilon_z = f\left(\varepsilon_\varphi\right) \qquad (1)$$

in the form of it tabular a given function. Strains ε_z and ε_φ are defined as natural logarithms of ratios of current sizes to the initial 0.

In 0 approximation of dependence (1) in the form of the differential equation with separable variables is offered

$$\frac{d\varepsilon_z}{d\varepsilon_\varphi} = -\frac{1}{2} - \frac{3}{2} \cdot \frac{m^2}{\varepsilon_\varphi^2 + m^2} \tag{2}$$

where *m*>0 – experimentally a definable constant.

Taking into account starting conditions

$$\varepsilon_z|_{\varepsilon_\varphi=0} = 0 \tag{3}$$

by the solve of the differential equation (2) we will obtain

$$\varepsilon_z = -\frac{1}{2}\varepsilon_\varphi - \frac{3}{2} \cdot m \cdot arctg\left(\frac{\varepsilon_\varphi}{m}\right) \tag{4}$$

It follows that

$$\lim_{m\to\infty} \frac{d\varepsilon_z}{d\varepsilon_\varphi} = -2, \qquad \lim_{m\to 0} \frac{d\varepsilon_z}{d\varepsilon_\varphi} = -\frac{1}{2}. \tag{5}$$

It means, that at enough great values m, according to (4), with a high accuracy the equality follows

$$\varepsilon_z = -2 \cdot \varepsilon_\varphi \tag{6}$$

what corresponds to the kind of strain - compression, and at enough small values *m* –

$$\varepsilon_z = -\frac{1}{2}\varepsilon_\varphi \tag{7}$$

what corresponds to the kind of strain – tension. Taking into account an incompressibility condition we will gain $\varepsilon_r = \varepsilon_\varphi, \varepsilon_r = \varepsilon_z$ accordingly at compression and a tension, where ε_r - the radial plastic strain. Thus, changing friction at end faces at axisymmetric compression of the cylindrical blank between plane-parallel slabs, we will gain experimentally different dependences (4). These dependences can be approximated by the relation (4) by selection of value of a constant *m*. Here it is important, that the constant *m* is necessary invariable at testing of the particular blank or, that too, friction conditions at end faces are guessed invariable.

On the figure 1 results of experimental and calculation data are presented. Parametre value m for each curve determined by method of least squares. The method of least squares with use of a relation (4) leads to necessity of the solution of a transcendental equation of the complicated structure. Therefore values *m* determined by means of add-in Microsoft Excel Solver by minimizing of the total of quadrates of residuals.

Transforming relations (4) into the parametric shape, we will obtain 0

$$\begin{cases} \varepsilon_\varphi = m \cdot tg(x) \\ \varepsilon_z = -\frac{m}{2} \cdot (tg(x) + 3 \cdot x) \end{cases} \tag{8}$$

where *x* – parameter.

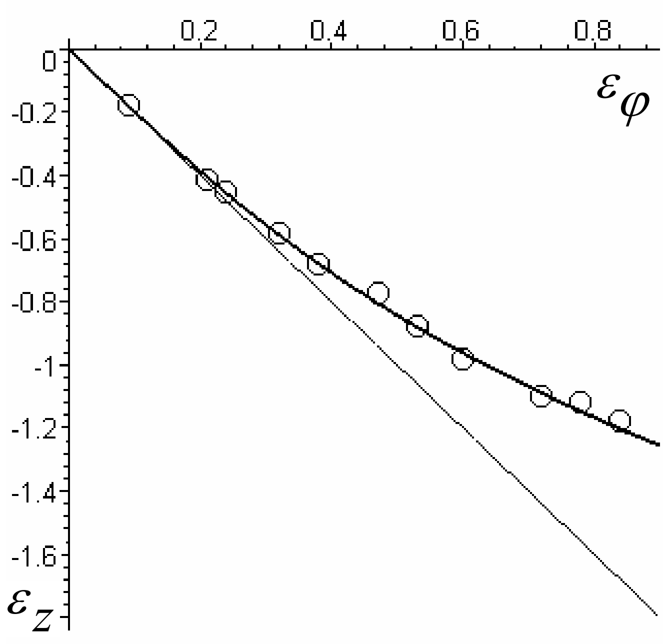


Figure 1. Dependence between axial ε_z and hoop ε_φ strains: ;- $\varepsilon_z = -2 \cdot \varepsilon_\varphi$; ———— - calculation based on (4) at m=0,51; o – experimental data.

The accumulated plastic strain it is determined as

$$\varepsilon_u(t) = \int_0^t \dot{\varepsilon}_u(\tau)d\tau, \tag{9}$$

where *t*, τ – time; $\dot{\varepsilon}_u$ is the intensity of velocities of strains

$$\dot{\varepsilon}_u = \frac{2\sqrt{3}}{3}\sqrt{\dot{\varepsilon}_z^2 + \dot{\varepsilon}_z\dot{\varepsilon}_\varphi + \dot{\varepsilon}_\varphi^2} \tag{10}$$

Using relations of the flow theory we will obtain principal stresses σ_z, σ_φ (on a free surface $\sigma_r = 0$). The index of a stress state,which equal to the division of the first invariant of a stress tensor on stress intensity. This index is equal 0-0

$$\eta = \frac{1-3\cdot\cos^2(x)}{\sqrt{1+3\cdot\cos^4(x)}} \tag{11}$$

The curve of the plastic strain, which accumulated up to fracture at stationary deformation we will approximate by function

$$\varepsilon_{*c}(\eta) = \varepsilon_{*c}(\eta = 0)\cdot\left(\frac{(1-\eta)\cdot\varepsilon_{*c}(\eta=-1)}{2\varepsilon_{*c}(\eta=0)} + \frac{(1+\eta)\cdot\varepsilon_{*c}(\eta=0)}{2\varepsilon_{*c}(\eta=1)}\right)^{-\eta} \tag{12}$$

where $\varepsilon_{*c}(\eta = -1), \varepsilon_{*c}(\eta = 0), \varepsilon_{*c}(\eta = 1)$ - plastic ultimate strain under compression, torsion and a tension accordingly.

Definition of ultimate strains at a non-stationary deforming 0 we will fulfil by on two models.

Kolmogorov's scalar model, 0, 0, 0, is based on a linear principle of accumulation of damage

$$\psi(\varepsilon_u) = \int_0^{\varepsilon_u} \frac{d\varepsilon_u}{\varepsilon_{*c}[\eta(\varepsilon_u)]} \quad (13)$$

where ψ - macroparticles's damage, which varies from 0 in an initial state up to 1 at reaching of the limiting state; $\varepsilon_{*c} = \varepsilon_{*c}(\eta)$ - curve of the plastic strain, which accumulated up to fracture at stationary deformation. Value $\varepsilon_u = \varepsilon_*$ at which equality $\psi = 1$ is attained is the limiting value of the accumulated plastic deformation before macrodamage occurrence.

The tensor-linear model which is based on a linear principle of accumulation of damage 0

$$\psi_{ij}(\varepsilon_u) = \int_0^{\varepsilon_u} \frac{\beta_{ij}(\varepsilon_u)}{\varepsilon_{*c}[\eta(\varepsilon_u)]} \cdot d\varepsilon_u \quad (14)$$

where β_{ij} - the direction tensor of the strains increments, defined by equality

$$\beta_{ij} = \frac{d\varepsilon_{ij}}{\sqrt{d\varepsilon_{ij} d\varepsilon_{ij}}} \quad (15)$$

$d\varepsilon_{ij}$ - increments of plastic deformations. Limiting value of the accumulated plastic deformation before macrodamage occurrence $\varepsilon_u = \varepsilon_*$ it is determined from of a condition of reaching by the second invariant of a deviator of damage of the limiting value:

$$\psi_{ij}(\varepsilon_*)\psi_{ij}(\varepsilon_*) = 1 \quad (16)$$

On the figure 1 results of calculations of dependence of an ultimate strain from parametre *m*, which characterize distortion intensity are presented.

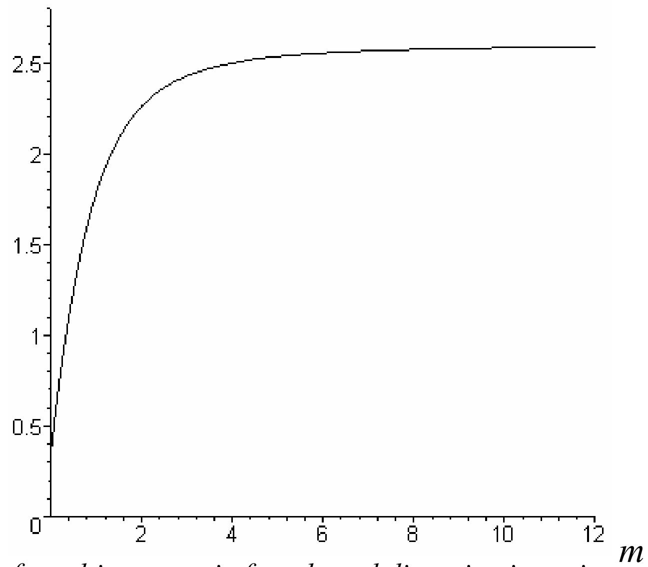


Figure 2. Dependence of an ultimate strain from barrel distortion intensity for steel 10: calculation based on (13) and (14), (16).

From the data presented on figure 2, follows, that calculations based on Kolmogorov's model (13) and on tenzorno-linear model (14), (16), on a drawing are indistinguishable.

3. Conclusions

At barrel distortion intensity magnification the ultimate strain is diminished. The peak discrepancy with value on curves of ultimate strains at the stationary and nonstationary deformation is observed at $m \approx 0,5$. The mathematical apparatus presented in given paper allows to describe and investigate legitimacies of a modification of ultimate strains on a cylindrical blank's free surface at its plastic axisymmetric compression between plane-parallel slabs. The given apparatus is applied both to development of the theory of deformability, and for its practical use at projection of technological process of plastic working.

Received November 24, 2008 *Vinnytsia National Technical University, Ukraine*

REFERENCES

1. Smirnov-Alyaev, G. A., **Resistance of Materials to Plastic Deformation** [in Russian], Leningrad: Machine building, 1978. - 368 p.
2. Ogorodnikov, V.A., **Deformability and fracture of metals at a plastic forming** [in Russian], Kiev: UMK VO, 1989. - 152 p.
3. Lebedev, A. A., Mikhalevich, V. M., **On the Choice of Stress Invariants in Solving Problems of Mechanics//Strength of Materials** N 35 (3), Plenum Publishing Corporation (USA), May - June, 2003, 217-224.
4. Mykhalevych, V.M., **Tensor models of damage accumulation** [in Ukranian], Vinnitsa "UNIVERSUM - Vinnica", ISBN 966-7199-20-7, 1998. - 195 p.
5. Kolmogorov, V. L., **Stresses, Strains, Fracture** [in Russian], Metallurgiya, Moscow, 229 p.

DEPENDENTA TENSIUNII DE DEFORMARE PLASTICĂ

Rezumat: Se studiază compresia asimetrică a unei epruvete cilindrice între plăci plan-paralele. Sunt prezentate procedeul, modelul matematic şi programul de calcul al modului de deformare.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

WHEN SYSTEM RELIABILITY TECHNIQUES ARE USED TO AUDIT MANUFACTURING SUPPLIERS IN OCCUPATIONAL HEALTH AND SAFETY

BY

S. NADEAU, B. JULIEN ET J. ARTEAU

Abstract: Checklists are often used to evaluate manufacturing suppliers. New production methods require frequent review of these lists in optimizing and automating the auditing process. This paper sets out and illustrates the innovative use of a technique with which to evaluate inter-functional performance with respect to occupational health and safety among manufacturing companies: a necessary audit to take a supplying decision.

Keywords: integrated prevention, occupational health and safety risks, operational risks, supplying, audit.

1. Introduction

How might a team of two (2) auditors in half a day evaluate and offer a plan to improve the performance of a company?

A number of methods might be used to evaluate the performance of suppliers, the main ones being:

- ❖ Accounting systems such as the financial ratios pyramid developed by Dupont (1);
- ❖ The performance measurement matrix advanced by Keegan et al. (2);
- ❖ Score Card (3);
- ❖ Balanced Score Card (4);
- ❖ Performance prism (5).

Identifying measures needed for improved competitiveness and performance remains difficult in the absence of an established and ongoing process by which to implement such improvement and a comparison with firms in the same field (6).

Benchmarking serves to attain the twin goals of evaluation and improvement (7,8,9) and has been recommended by the Government of Quebec (10). It results in the identification of best practices, techniques, methods, procedures or processes that have contributed toward improvement in the performance of an organization (11). Benchmarking processes currently in use to rate suppliers typically rely on a checklist; a questionnaire listing hundreds if not thousands of questions. The content of these lists needs to be revised more thoroughly and quickly owing to new production contexts, the need to optimize and automate the audit process, a process constrained by time, the extent to which information, monetary and human resources are available. The assessment process serves as much as in the selection of suppliers as it does in the continuous improvement in activities of the latter, recommendations of performance auditors leading to decisions having very real consequences for firms (12).

Accordingly, it is essential to limit occurrences of bias (level errors, errors of omission, errors in certain variables or parameters related to methods of evaluation).

The goal of this study has been to set out an explicit and innovative model in support of the diagnostic work carried out by performance auditors in manufacturing firms. This goal was attained through the use of an operating safety technique (fault-tree analysis) to assess performance of a manufacturer relative to risks (potential performance weaknesses or performance failures (13)).

2. Methodology

We took a descriptive approach to the problem of evaluating suppliers. Consequently, we reviewed assessment criteria used in the industry accompanied by a review of the literature aimed at identifying best practices. We have identified variables in the assessment criteria in order to obtain the information needed to raise or quantify them. We have used fault-tree analysis to model the causal links among these criteria.

3. Results

We first carried out a review of the literature to identify best manufacturing practices by field of endeavour. We adopted a holistic approach to devise a business system for eleven (11) functions: administration, production, engineering, purchasing, marketing, maintenance, accounting and finance, occupational health and safety, quality, environment and human resources. Each best practice has been translated into criteria for assessment. We have subjected each criterion to the following questions:

- What criteria need to be added to those identified for the evaluation of suppliers?
- What are the main variables to be addressed? What data are required to raise or quantify these variables?
- What criteria need to be detailed or studied in depth?
- What constraints must be respected?

These criteria were then structured and arranged in a hierarchy while respecting basic tenets of management (14), using the modeling and nomenclature set out in figures 1.1 and 1.2.

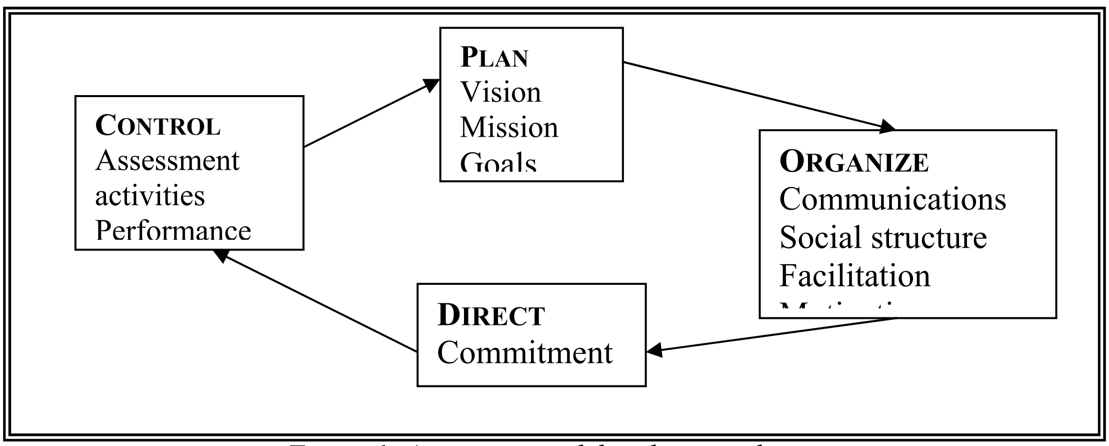


Figure 1. Aggregate model and nomenclature

Without planning, activities necessary to the organization of a business lack goals. An organization without goals cannot be directed and, without direction, lacks the level of control possible.

Figure 1.2 sets out an example of nomenclature. To carry out the planning of activities, it is necessary, among other things, to determine whether the firm has formulated a vision or mission. To formulate a mission adequately, among other considerations it needs to be documented and communicated. This nomenclature makes it possible simultaneously to specify the dependent links among various levels of the audit model and to limit information sought by the auditor to subjects that are pertinent to the performance appraisal.

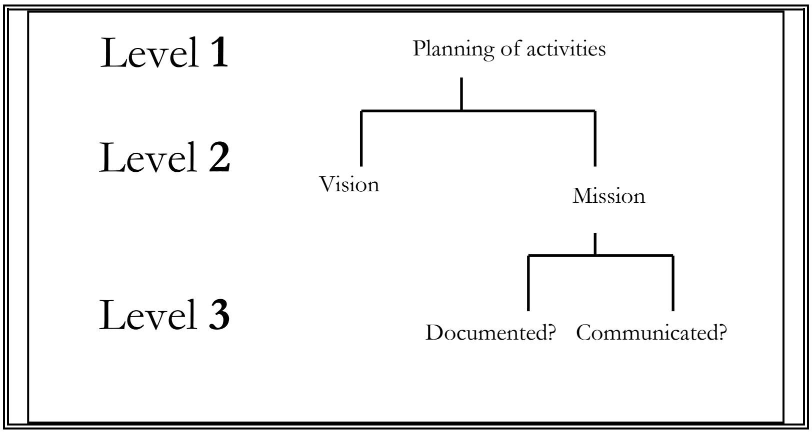


Figure 2. Nomenclature example.

Fault-tree analysis was used to establish close ties among the criteria set out in Levels 1 and 2. Fault-tree analysis is an operating safety technique conceived in 1961 by H.A. Watson at Bell laboratories under a contract with the U.S. Air Force (13). Developed to assess and improve the reliability of the system used to launch the "Minuteman" missile, it proved instrumental in eliminating many failures in this project. Following the Safety System Symposium in 1965 (15), this technique was applied as a tool to gauge the safety and reliability of complex dynamic systems, notably in the nuclear and aerospace industries. Its use today extends to the modeling of processes for which it is necessary to identify critical scenarios leading to an undesirable event.

Fault-tree analysis makes it possible, through a detailed deductive approach, to highlight performance links existing in ideal manufacturing firms. The performance of one activity can be dependent on the performance of another activity in the same area (intra-operational) or in another area (inter-operational).

For example, the following model has been used to study intra-operational causes in the occupational health and safety function. This model sets out systematic and systemic analysis, control and management of risks consistent with recommendations put forward by institutions and specialists recognized in the field (16÷19).

Occupational health and safety planning starts with the formulation of a policy concerning workplace health and safety. Such a policy leads to delineation of a vision and commitment on the part of the organization, resolved to comply with legal requirements, embrace preventive goals, dedicating the resources and means required to act in a preventative mode and clarifying how information will be communicated concerning risks existing in the workplace.

To reach its preventive goals, the firm must first identify occupational health and safety problems found in the workplace. To do this, the firm first carries out a survey and analysis of accidents (and sometimes incidents), inspects premises, analyzes risks and their effects.

Once risks have been identified, the firm may choose to act at the source or on the conductive path of an occupational health and safety problem. Typically, the means used to control risks are as follows: eliminating risk by altering the design, limiting dangerous parameters, introducing isolating devices, tagouts, energy dissipating devices, lockout features, supply of personal protective equipment, cribs, etc.

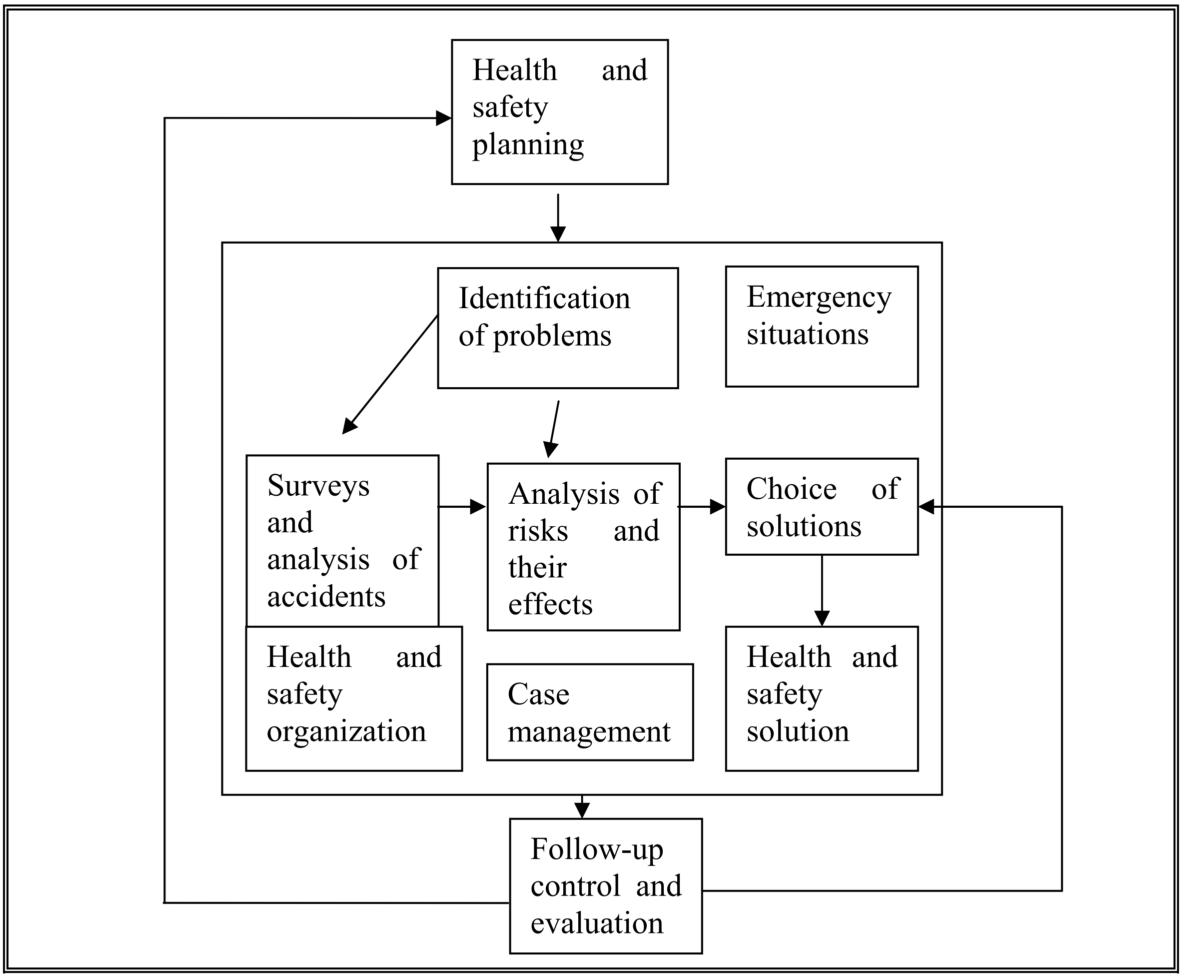


Figure 3: Model of the intra-operational links for occupational health and safety.

Study of inter-operational causes using fault-tree analysis leads us to conclude that performance of preventative activities in occupational health and safety (OHS) is affected, among other things, by (see figure 4):

- ❖ Performance of activities relating to supply, design and maintenance. Twenty (20) workers a year in Quebec die as the result of failures related to occupational health and safety. Eight per cent (8 %) of accidents covered by insurance in Quebec, numbering thirteen thousand (13 000) annually (20) involve dangerous machinery of all types. Accelerated technological developments bring with them new risks that need to be identified, measured, analyzed and controlled. Consequently, it becomes essential to address safety issues from the moment decisions are made concerning outside purchases, internal design or preventive and scheduled corrective maintenance;

❖ Performance in the areas of human resources and the supervision of production (or management of operations); these functions are, among other things, responsible for the organization of work, recruitment and training of staff, and response to known variables (such as those identified in the abundant literature dealing with ergonomic intervention), all having a considerable impact on OHS.

ADM1: INTEGRATED PLANNING OF ACTIVITIES
ADM3: OPERATIONS MANAGEMENT
ING3: ENGINEERING ACTIVITIES
MTN3 : MAINTENANCE, HEALTH AND SAFETY
PRD3: PRODUCTION ACTIVITIES
PRD12: WORKING INSTRUCTIONS
RHM4: HUMAN RESOURCES TRAINING PROGRAM
SAS: HEALTH AND SAFETY
SAS1: HEALTH AND SAFETY PLANNING
SAS2: HEALTH AND SAFETY ORGANIZATION
SAS3: IDENTIFICATION OF PROBLEMS
SAS4 : SURVEY AND ANALYSIS OF ACCIDENTS
SAS5 : RISK ANALYSIS
SAS6 : MANAGEMENT OF DANGEROUS GOODS
SAS7 : CHOICE OF SOLUTIONS
SAS8: HEALTH AND SAFETY SOLUTIONS
SAS9: ACCIDENT CASE MANAGEMENT
SAS10: EMERGENCY MANAGEMENT
SAS11: HEALTH AND SAFETY ASSESSMENT

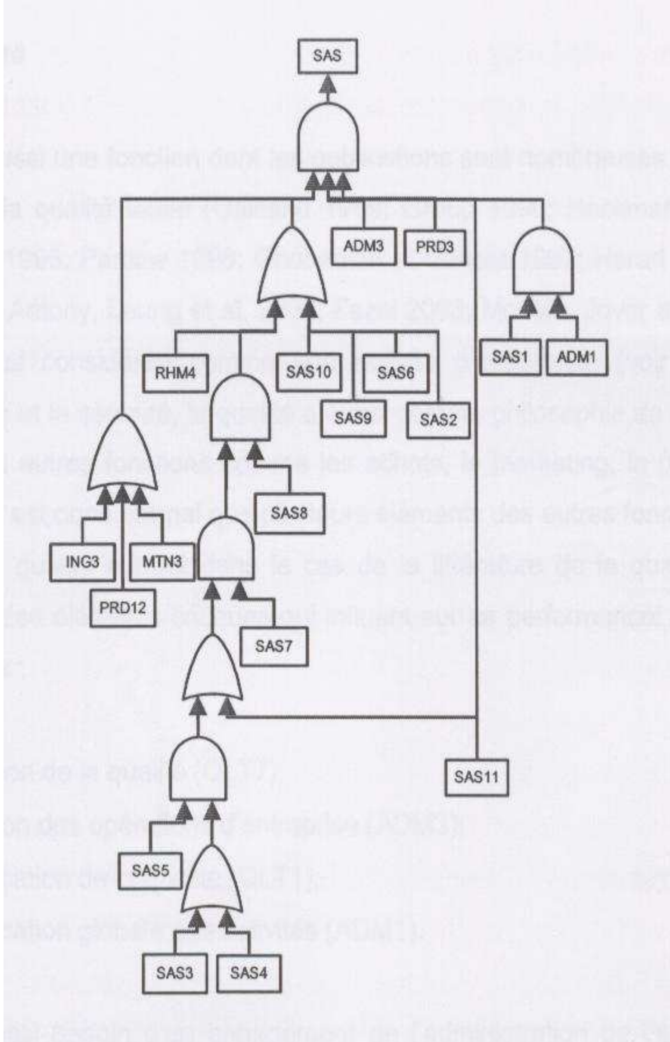


Figure 4. Example of inter-operational fault-tree causes in evaluating performance in occupational health and safety.

Fault-tree analysis using bolean mathematics lets us calculate the level of risk or reliability of the system that it models. So the formulation of the questionnaire, based on the criteria set out for performance assessment, has been reviewed in its entirety, resulting in an audit questionnaire that classes responses as “affirmative” or “negative”, followed by comment from the auditor. Responses chosen are assigned a value of 1 (affirmative) or 0 (negative). Accordingly, fault-tree causes in figure 1.4 can be reduced to a mathematical equation expressed as follows:

(SAS3+SAS4)*SAS5)+SAS11)*SAS7)*SAS8)+RHM4+SAS10+SAS9+SAS6+SAS)
*ADM3*PRD3*SAS11*(SAS1*ADM1)*(ING3+PRD12+MTN3)

By analyzing the causes, we can target those activities that are critical for the company, facilitating the identification of corrective actions that will prove both efficient and effective, in a supply process perspective.

Lastly, the model has been validated by a partner specializing in the assessment of performance and competitive benchmarking, SOUS-TRAITANCE INDUSTRIELLE QUÉBEC (STIQ). This tool is currently used by this non-profit private firm which is a leader in the field of research, evaluation and improvement of suppliers/subcontractors. A prototype for computer-based support, using WEB technology and tested in BETA mode, has been proposed, which meets requirements under the company's ISO-registered quality assurance program and developed in collaboration with a team of software engineers from l'École de technologie supérieure (ÉTS). The audit questionnaire is confidential and marketed under the brand name DiagnoSTIQ®.

4. Discussion

Performance assessment based on highlighting and adopting best practices identified and known in the industry concerned ought to be viewed as a reliable tool. However, it is limited by the exchange of know-how and knowledge of this subject. Scientific intelligence is essential in keeping the audit tool up to date.

Modeling through the integration of a number of functions meets the needs and broad issues addressed in business systems that are growing more and more complex and dynamic (21,22). A number of paths have been explored recently with respect to the integration of OHS, for example:

- ❖ In the management of quality and the environment (23);
- ❖ In corporate management systems (24), using total quality (25) or remuneration models (26);
- ❖ In the design of manufacturing systems (27,28,29)
- ❖ In organizational factors and in control of major risks (30).
- ❖ In the planning of manufacturing systems (31,32,33).

The originality of the model proposed here resides in the integration of a number of functions by making use of an operating safety technique already proven in the nuclear and aerospace industries.

Fault-tree analysis always poses the challenge of identifying all modes of failure, although it works extremely well in analyzing systems (34). In fact, fault-tree has the advantage of being deductive, graphic, logical and adaptable as much for qualitative as for quantitative analysis. However, modeling thus obtained is limited by the degree to which the analyst knows the system, its dynamic and its evolution. The calculation of performance for each function based on bolean logic excludes performance partially realized.

5. Conclusion

Evaluating sources of supply, at both the technical and technological levels, is inescapable and accelerating in a global economy. Growing integration of technological and economic systems complicates choice among a number of suppliers.

It is necessary to take into consideration close interactions between the internal and external environments of companies as well as the impact of increasingly interactive human environments. The assessment of suppliers serves not only to establish (or reinforce) business relationships that are most rational, but also promotes improved competitiveness because firms are better able to identify industrial practices that are both efficient and effective, acknowledged by experts in quality or supply.

We have given SOUS-TRAITANCE INDUSTRIELLE QUÉBEC (STIQ) a performance assessment tool for manufacturing companies based on fault-tree analysis, a well-known approach to operation safety. This is a more complete and integrated approach and innovative tool to perform audits and implement improvements more quickly.

6. Acknowledgements

This research project has been made possible thanks to the financial support of SOUS-TRAITANCE INDUSTRIELLE QUÉBEC (STIQ), Mouvement Desjardins, l'École de technologie supérieure (ÉTS) and the Natural Sciences and Engineering Research Council (NSERC).

Received November 19, 2008

École de technologie supérieure, Montréal, Canada

REFERENCES

1. Chandler A.D., **The visible hand – managerial revolution in American business**, Harvard University Press, (1977) Boston.
2. Keegan D.P., Eiler R.G., **Are your performance measures obsolete? Management Accounting**, (1989) 45(1), 91-97.
3. Lebas M., **Management Accounting Practice in France**, Oxford University Press, (1996) Oxford.
4.. Kaplan R.S and Norton D.P., **The balanced scorecard: translating strategy into action**, Harvard Business School Press, (1996) Boston.
5. Neely A., Adams C. *et al.*, **The performance prism in practice measuring excellence**, The Journal of Business Performance Management, (2001) 5(2), 6-12.
6. Wisner J.D.,. Leong G.K *et al.*, **Principles of supply chain management**: a balanced approach, Mason, Ohio: South-Western (2005).
7. Forker L.B. et Mendez D., **An Analytical Method for Benchmarking Best Peer Suppliers**, International Journal of Operations and Production Management, 21(1/2), (2001) 195-209.
8. Kyro P., **Revising the concept and forms of benchmarking**, Benchmarking: an International Journal, 10(3), (2003) 210-225.
9. Maire J.L., Bronet V. *et al.*, **A typology of «best practices» for a benchmarking process**, Benchmarking: an International Journal, 12(1) (2005), 45-60.
10. Gouvernement du Québec, **Stratégie québécoise pour améliorer la compétitivité des enterprises** (2001).
11. Zahorsky D., **Small business best practice benchmarking – how to effectively borrow ideas, strategies and tactics**, (2003) http://sbinformation.about.com/library/weekly/aa011903a.htm.
12. Vondetembse M.A. and Tracey M., **The impact of supplier selection criteria and supplier involvement on manufacturing performance**, Journal of Supply Chain Management, 35(3) (1999), 33-39.
13. Haimes Y.Y., **Risk modeling, assessment and management**, John Wiley & Sons Inc, Hoboken, New-Jersey, (2004).
14. Wilson P.F.,. Dell L.D *et al.*, **Root cause analysis: a tool for total quality management**, Milwaukee: ASQC Quality Press (1993).

15. Villemeur A., **Sûreté de fonctionnement des systèmes industriels**, Éditions Eyrolles, Paris. (1988).
16. Department of Defence, **Standard practice for system safety**. MIL-STD-882D (1993), 27 pages.
17. CRAMIF, **Sécurité des équipements de travail**, Guide pour l'analyse des risques et le choix des mesures de prévention, Service de prévention des risques professionnels, DTE 127, France (2002).
18. Pâques J.J. and Bourbonnière R., **Formation sur l'appréciation du risque sur les machines dangereuses et les moyens de protection**, IRSST, Canada, (2002).
19. Ricard S., **Cadre de référence en gestion des risques pour la santé dans le réseau québécois de la santé publique**, INSPQ-2003-014, Institut national de santé publique du Québec, Canada, (2003)
20. Commission de la santé et de la sécurité du travail (CSST), Rapport annuel d'activité 2004, Québec.
21. Gomes C.F., Yasin M.M. *et al.*, **An examination of manufacturing organizations' performance evaluation: analysis, implications and a framework for future research**, International Journal of Operations & Production Management, 24(5) (2004), 488-513.
22. Le Coze J.C., **Are organisations too complex to be integrated in technical risk assessment and current safety auditing?** Safety Science, 43 (2005), 613-638.
23. Labodovà A., **Implementing integrated management systems using a risk analysis based approach**, Journal of Cleaner Production, 12 (2004), 571-580.
24. Walker D., **Measuring Corporate Health and Safety Performance – the Value of a Universal Indicator**, Inst.Chem.Eng.Symp no 151 (2006), 631-640.
25. Zinc K.J., **From Industrial Safety to Corporate Health Management**, Ergonomics, 48(5) (2005), 534-546.
26. Toupin D., Lebel L., Dubeau D., Imbeau D.and Bouthillier L., **Measuring the productivity and physical workload of brushcutters within the context of a production-based pay system**. Forest Policy and Economics, 9 (2007), 1046-1055.
27. Drais, **La capacité prescriptive des systèmes de management de la sécurité : une comparaison dans le BTP**, SELF congress (2005), 335-346.
28. Winkel J.and Neumann P., **Ergonomics and effective production systems – moving from reactive to proactive development**, National Institute for Working Life, Info 2005:07, Sweden.
29. Claudon L., Daille-Lefèvre B. and Marsot J., **La révolution du numérique: un atout pour concevoir des postes de travail plus sûrs.** Hygiène et sécurité du travail, 210 (2008), 5-13.
30. Bellamy L., Geyer T.A.W. and Wilkinson J., **Development of a Functional Model which Integrates Human Factors**, Safety Management Systems and Wider Organisational Issues. Safety Science. (2006)
31Saurin. T.A., Formoso C.T. and Guimaraes L.B.M, **Safety and production: an integrated planning and control model**, Construction Management and Economics, 22 (2004), 159-169.
32. Hare B., Cameron I., and Roy Duff A., **Exploring the Integration of Health and Safety with Pre-contruction Planning, Engineering, construction and architectural management**, 13(5) (2006), 438-450.
33. Charlot E.,. Kenné J.P and Nadeau S., **Optimal production and lockout/tagout control policies in manufacturing systems**, International Journal of Production Economics, 107 (2006), 435-450.
34. Roland H.E. and Moriarty B., **System Safety Engineering and Management**. John Wiley & Sons, (1990), 367 pages.

UTILIZAREA TEHNICILOR SECURITATE PENTRU EVALUAREA FIRMELOR PRODUCATOARE DIN DOMENIUL SĂNĂTĂȚII ȘI SECURITĂȚII ÎN MUNCĂ

Rezumat: Evaluarea furnizorilor (firme producatoare) se bazeaza deseori pe o lista de control. Dinamica noilor metode de productie impun o revizuire frecventa a continutului acestor liste, o optimizare si o automatizare a procesului de audit. Prezentul articol propune si ilustreaza o utilizare originala a unei tehnici de siguranta in functionarea echipamentelor (fiabilitate) pentru evaluarea inter-functionala a performantei firmelor producatoare in domeniul sanatatii si securitatii in munca ; un audit necesar luarii unei decizii de aprovizionare.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

RESEARCH CONCERNING COOLING ENVIRONMENT TEMPERATURE INFLUENCE OF HARDENING ON THERMAL TRANSFER BETWEEN ENVIRONMENT AND SAMPLE

BY

CARMEN NEJNERU, ADRIAN GRECU, RAMONA HANU CIMPOESU and ION HOPULELE

Abstract: Cooling environment temperature has an important influence on cooling intensity of hardening environment. In this paper was made a comparing study between cooling environments for water quenching at 20, 40, 60 and 80 cesium degree determining cooling curves of a standard silver sample.
Based on this curves was calculated the cooling rates as well as thermal transfer coefficient sample-environment for different cooling periods. In every cases was calculate the cooling intensity also.

Keywords: thermal transfer coefficient, cooling environments, cooling curves, cooling intensity

1. Introduction

Cooling, as final operation of thermal treatment, have a special importance because she got the role of determining structure and implicitly the properties of thermal treat samples.

For a right chose of a cooling environment is analyzed the kinetic cooling curve of alloy (T.R.C. diagram) and compare with cooling curves of environments.

The correctly proceeding of cooling process at hardening has an important place for operation success with a view to obtain certain structures in samples section (hardening structures type martensitic) without produce hardening defects like: cracks, deformations or to big remanent tensions.

The oil have a very appreciate curve at cooling because of fast passes through minimal stability domain of subcooled austenite (A) and have a reduce rate of cooling in martensitic transformation domain (B) when tensions owed structures transformations are very big ($v_{specific\ \underline{M}} > v_{specific\ \underline{A}}$) and thermal tensions made by cooling rate are smaller.

But the oil have disadvantage that present a high ignition danger, is a no-ecological environment (because of gas emanations which appear during hardening), for this was search replacement of mineral oil for thermal treatment there were is possible with cooling alternatives with reduce or none start ignition danger which can be the synthetic environments.

By these considerations in big hardening bathes from industry at this time is used carboximetil cellulose 4%. During function the hardening bath properties are modified by her self that’s way is necessary the presence of some additives which can confer constancy in properties and o good cooling capacity function of steel type and every sample type.

Another very important factor is representing by environment agitation degree which modify substantially the cooling curve, implicit instantaneous cooling rates and thermal transfer coefficient on different periods.

2. Experimental results

For cooling capacity determination of an environment is use a cylindrical sample made of silver, with dimensions presented lower, which have in center installed a thermocouple type chromel-alumel which permit temperature measurement using an y-t writer. The sample is heated at needed temperature (temperature of 800ºC) and cooled in environment choose for analyze.

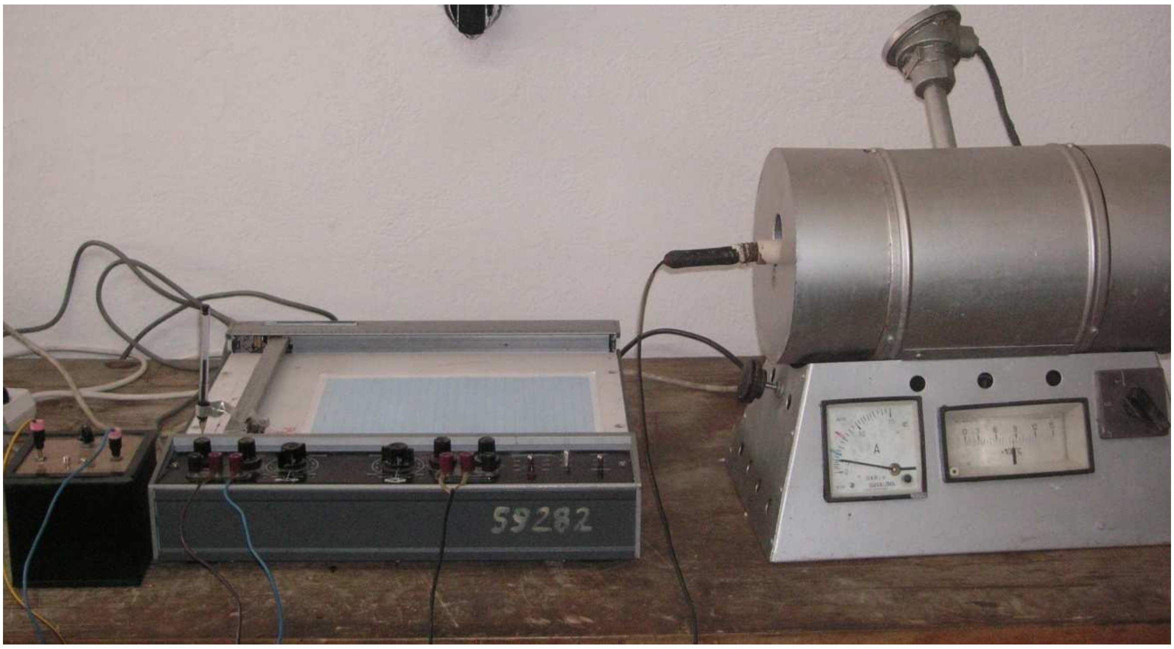


Figure 1. Equipment image for cooling characteristics determination

Figure 2. a - writer y-t, b - time base

Silver sample have the next characteristics and dimensions: Ø = 12,5 [mm] , h= 25 [mm], S = 1408 [mm^2], m= 39.9 [g], ρ_{silver} = 10.5 g/cm^3, λAg = 418.5 W/m·

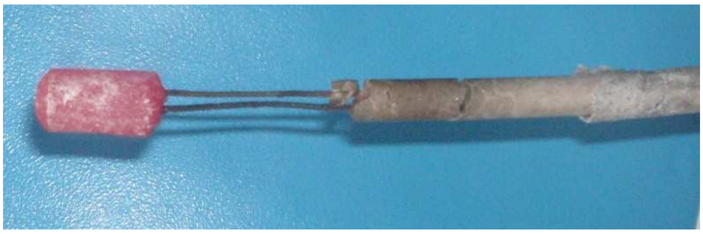


Figure 3. Silver sample

Equipment, in globally is presented in figure 1 and contain next primary elements:

- Silver sample
- cooling precinct
- furnace
- electric power supply
- Chromel-Alumel thermocouple
- millivoltmeter for indication
- recorder OH 816/H

The sample was heat in furnace until 800 ºC and after that was put in cooling environment researched, cooling curve being registered on y-t recorder.

For every cooling environment was calculated next parameters:

- cooling rate on intervals [^{o}C/s]
- thermal transfer coefficient on intervals.

$$\alpha_i = \frac{3600 \cdot m \cdot c}{\Delta t_i \cdot S} \ln \frac{T_i - T_o}{T_f - T_o} \quad \text{[W/m2k]}$$

where:

m = 0.0399 [kg] sample mass;
c = 0.056 [kcal/kg·grd] specific heat of silver;
S = 0.001408 [m^2] sample surface;
Δt [s] - time interval;
T_i T_f [^{o}C] - final and initial temperature on interval
T_o - environment temperature.

Results obtained was put in a table and based on them was made:

- cooling curves T = f (t)
- cooling rate variation versus temperature v_r = f(T).
- thermal transfer coefficient function of temperature α_i= f(T).

3. Conclusion

After study the cooling curves, made experimentally, is observe that heated water at 80 ºC chill with a smaller rate then water at 20 ºC; the temperature range between 800 and 150 ºC was roved in a time 4.2 bigger (1,5 seconds for water at 20 ºC and 5,8 seconds for water at 80ºC).

Cooling rate can be modifying trough water heating function of cooling necessity at hardening for diverse metallic materials.

Received November 23, 2008 **Technical University "Gh. Asachi" Iaşi*

REFERENCES

1. Nejneru Carmen, Galusca D.G., Grecu A, Carabet Roxana, **Researches looking the modification cooling capacity of hardening compounds in magnetic field**, Universitatea Tehnica Galati, octombrie 2007
2. Nejneru Carmen, Grecu A, Carabet Roxana, Hopulele I., **Researches concerning the reconditioning of hardening bathes in synthetic medium based on carbodimethyl cellulose**, Universitatea Tehnica Galati, octombrie 2007

CERCETĂRI PRIVIND INFLUENȚA TEMPERATURII MEDIULUI DE RĂCIRE LA CĂLIRE ASUPRA TRANSFERULUI TERMIC DINTRE MEDIU ŞI PROBĂ

Rezumat: Temperatura mediului de răcire are o mare importanță asupra capacității de răcire a mediului de călire. În lucrare se face un studiu comparative între diferite medii de răcire şi se trasează, de asemenea, curbe;le de răcire. Pe baza acestora s-au calculat vitezele de răcire şi coeficientul de transfer termic.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

THE MORPHOLOGY OF A MONOPLUS DROP WITH TITANIUM CARBIDE ELECTRODE DEPOSITED BY VIBRATING ELECTRODE METHOD

BY

CARMEN NEJNERU, MANUELA CRISTINA PERJU, ANDREI VICTOR SANDU, ROXANA GABRIELA CARABET, TUDOR RAILEANU, ANCA ELENA LARGEANU

Abstract: Monoplus coatings have been made with TiC electrode on ferrite-pearlite cast-iron by vibrating electrode method in order to analyze the dynamic of the coating. The coating is made of a multitude of monoplus drops and its qualities depend among others on the quality of a drop deposition, shape of a drop, the structure and the dynamic of the drop. The analysis realized on an electronic scanning microscope (SEM) and in the same time it realized an analysis of the micro-alloying elements distribution on the surface as well as the shape achieved from work impulse.

Keywords: electrospark alloying, scanning electron microscopy, coating surface.

1. Introduction

The superficial heat treatments with material supply are domains which interest a lot. Some of these domains are: the surfaces processing with laser beam light, diffusion treatments in plasma, coatings through heat spraying, thin layers deposits through CVD and PVD proceedings.

The vibrating electrode method belongs to the same class with the electric arc coatings. The principle of hardening through electric sparks of the metallic pieces consists in the fact that in case of sparking unloading under the pulsatory current take place the polar transport of the electrode material, which represents the anode, on the surface of the piece, which is the cathode. This material alloys the layer of the piece and by chemically combining with the atomic dissociated azotes from the air, the carbon and the material of the piece it forms a diffusion layer which is hardened and resistant to wear. In the superficial layer forms complex chemical reactions: azotizes, carbonitriding, very stable nitridings and quenching layers.

The deposition through vibrating electrode is, in essence, a pulsatory microwelding technique. This is a relatively chip heat process that was used for local coatings of the metallic surfaces with the same material as the electrode. Normally this process is producing well anchored coatings due to metallurgical links (local micromeltings).

Materials' coating is one of the most important methods for mechanical properties improvement of the metallic pieces. For example wear resistance of some soft metals can be substantially increased through this coating treatment with vibrating electrode that can increase metallic surface's hardness comparable to the refractory materials.

2. Experimental results

It was used for the experiment the ferrite-pearlitic grey cast iron to which the chemical composition is given in the table.

Table 1. Chemical composition of the basis material

C	Si	Mn	P	S	Cr	Ni	Cu	Mo
3.97	2.87	0.25	0.06	0.07	0.28	0.126	0.17	0.03

We have chosen the grey cast iron because the study depends on the implementation of the method within the technological processes of the piston rings which are made of cast iron and have a powerful wear on the exterior. This made us think that we could prolong the life of the piston rings by making this micro alloying treatment.

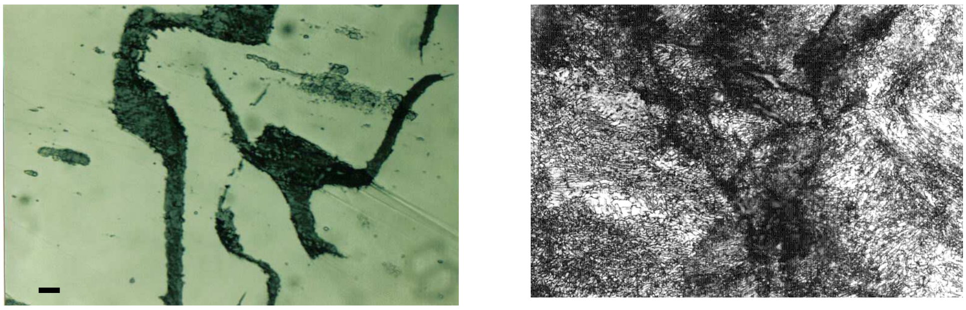
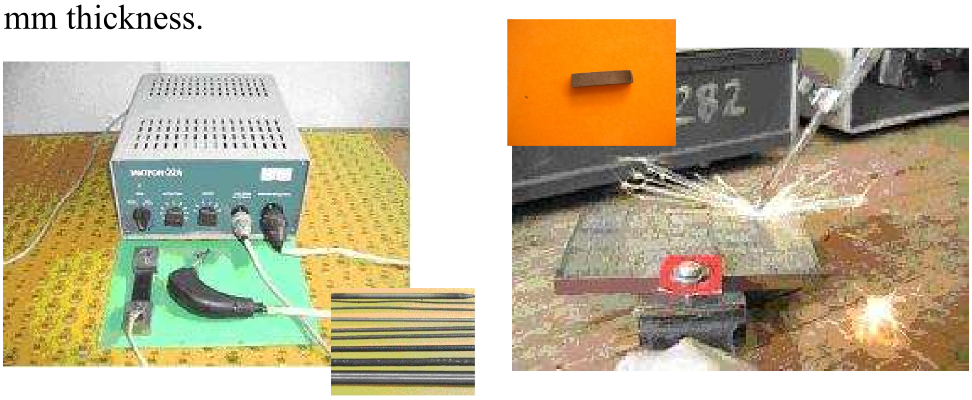


Figure 1. Basic material microstructure

The tests were made with an Elitron 22 apparatus. This can be found in Faculty of Materials Science and Engineering endowment. There were used a TiC electrode with 5 mm thickness.

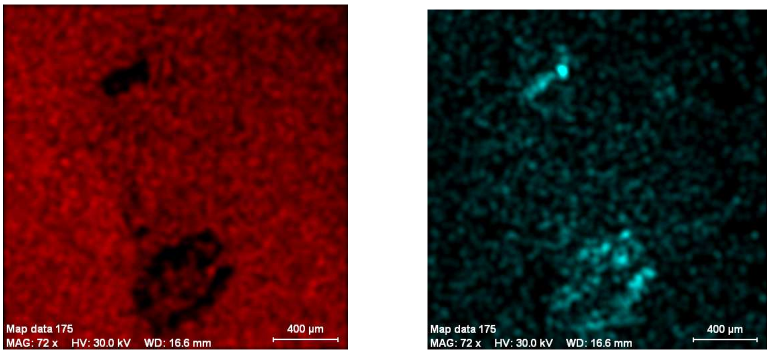


a) *b)*

Figure 2. a) Elitron 22 apparatus, used electrodes; b) Deposition regimes testing

The complex investigation of the sample took from cast-iron piece made on an electron scanning microscope, SEM, VEGA II LSH model, made by TESCAN Czech, with EDX detector type QUANTAX QX2, made by ROENTEC Germany.

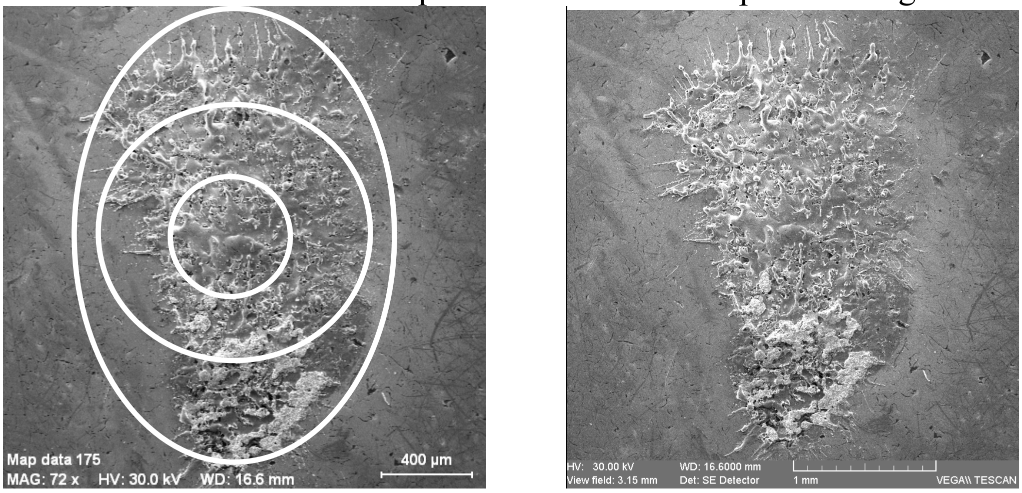
By studying the repartition map of the elements with X rays it notices the presence of Ti areas and a lot of C on the exterior of the drop due to the impulse created by the collision of the drop on the substrate.



a) SE_Fe b) SE_Ti

Figure 3. Elements repartition; a) Fe repartition; b) Ti repartition

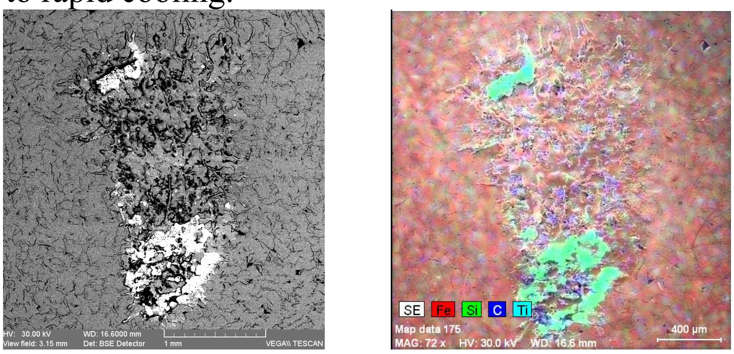
Titanium carbide drop shows a relative high dynamic of the splash and though drop's shape is not circular but lengthened. This thing happens due mainly to electrode shape and can be studied elements repartition within the drop and its edges.



a) SE_SE b) 70X se

Figure 4. Drop's shape achieved at SEM; a) TiC drop divided in study areas; b) microphotography through SE scanning

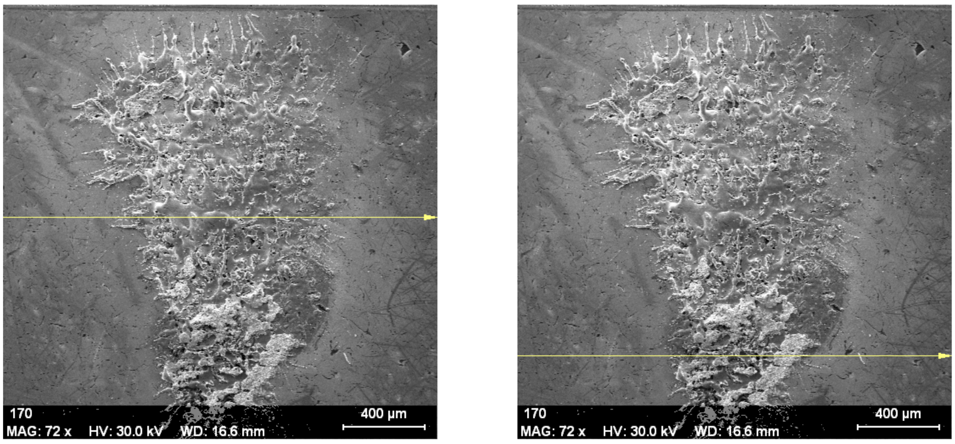
TiC drop even in lengthened conditions presents three distinct areas as shape and formation. In the first zone, the central zone of the material received a maximum collision impulse characterized by a stronger flattening and a better uniformity of the chemical elements according with the spectral analysis made with line 1. In the second zone it notices splashing form and it has intermediary character towards the third zone which is edge zone and has drops' heads with a non-uniform distribution than the rest. This appears due to rapid cooling.



a) 70X bse b) Map data 175

Figure 5. Drop shape achieved with SEM; a) Scanning microphotography through BSE; b) Chemical elements repartition on the surface of the coating (400µm)

In the center of the drop it notices an area with a uniform alloying emphasized by the line analysis, when Fe has 50 - 85%, the rest being Ti and C, so the area is mainly made of Fe carbide (cementite), titanium carbide and complex carbides.



linie 1 170 *linie 2 170*

Figure 6. Micrography of monopuls drop for line analysis

The fact that Ti is on drop's exterior it does not represent an inconvenient at deposition because in its circular movement the electrode comes back on the compact Ti microzone and melt it again by homogenizing the structure. The area with high concentration of Ti is emphasized in second line analysis too; in the same area Fe has 10-60%, and C and Ti the rest.

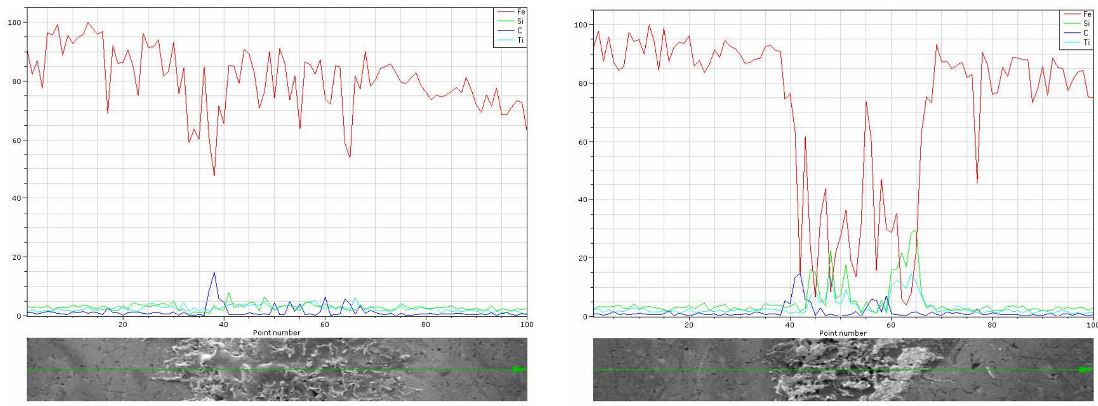


Figure7. Line analysis of TiC monopuls drop

3. Conclusion

- The study of monoplus drop and its morphology present important details for TiC deposition quality on the surface of the studied ferrite-pearlite cast-iron.
- Due to deposition dynamics it notices the presence of areas with Ti and C on the exterior of the drop caused by the impulse created by the collision of the drop on substrate.
- TiC has a good adherence on cast-iron surface without cracks.

Studying elements distribution it notices that TiC deposition is relatively compact due to high temperature from contact area, obtaining even a superficial micro alloying.

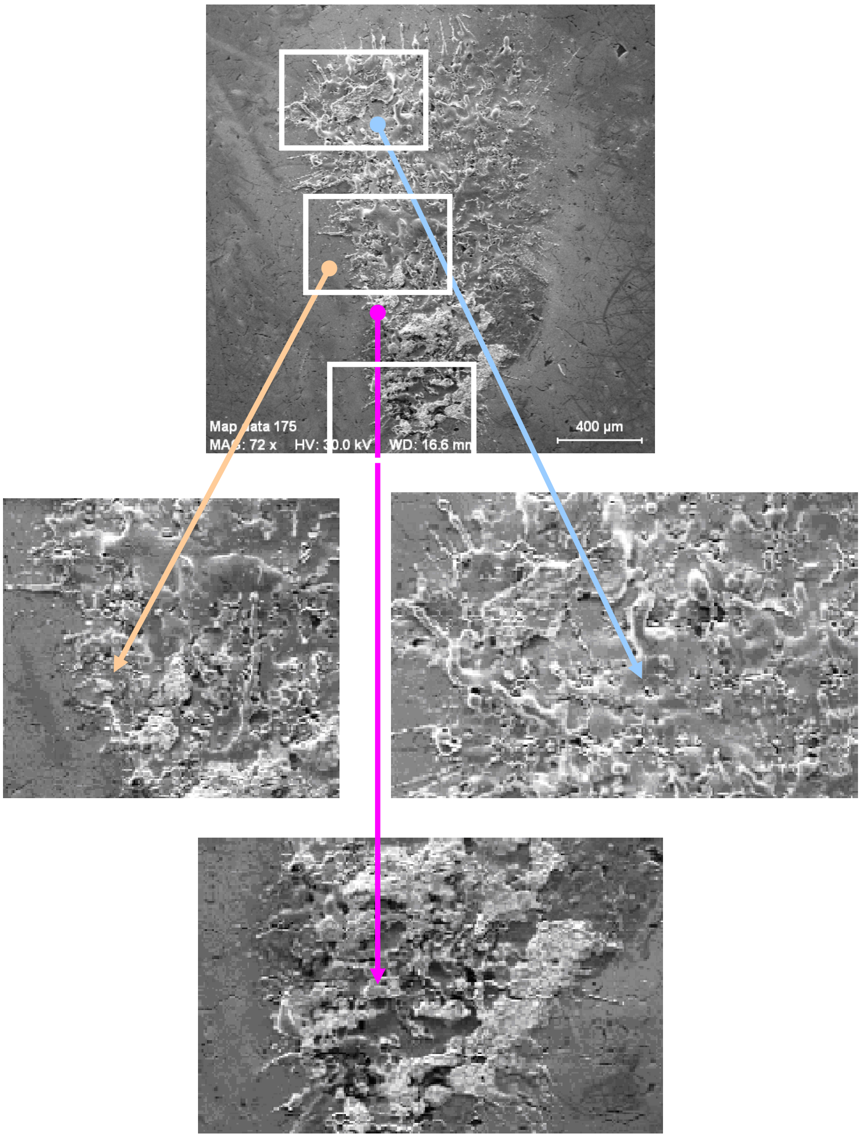


Figure 8. SE photography of TiC drop by emphasizing edge areas with drops and addition material and cast-iron.

Received November 23, 2008 *Technical University "Gh. Asachi" Iaşi*

REFERENCES

1. Raileanu, T., Teza de doctorat, **Contributia privind influienta unor tratamente termice din faza lichida asupra calitatii suprafetelor si rezistenta la uzare a unor repere din fonta**, 2000.
2. Vermesan, G., Vermesan, E., Jichisan-Matiesan, D., Cretu, A., Negrea, G., Vermesan, H., Vlad, M., **Introducere in ingineria suprafetelor**, Editura Dacia, 1999, ISBN 973-35-0922-1

MORFOLOGIA UNEI PICĂTURI UNIPULS CU ELECTROD DIN CARBURA DE TITAN DEPUSA PRIN METODA ELECTRODULUI VIBRATOR

Rezumat: S-au facut depuneri unipuls cu electrod de TiC pe suport de fonta ferito-perlitica prin metoda electrodului vibrator pentru analiza dinamicii depunerii. Stratul depunerii este format dintr-o multitudine de picaturi unipuls, iar calitatile acestuia depind printre altele si de calitatea depunerii unei picaturi, forma, structura

si dinamica acesteia. Analiza s-a realizat pe un microscop cu scanare electronica (SEM), realizandu-se in acelasi timp si o analiza a distributiei elementelor de microaliere pe suprafata, precum si forma obtinuta in urma impulsului de lucru.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

THE METALOGRAPHIC ANALYSIS OF STRUCTURE FROM SEALING AREA OBTAINED FROM PLASTIC DEFORMATION AND DIFFUSION ON SMALL DIAMETERS PIPES MADE FROM COPPER CU5

BY

***DAN RIDICHE, **OVIDIU CALANCIA, **ADRIAN DIMA, **DIANA-ANTONIA GHEORGHIU**

Abstract: This work presents the microstructure and macrostructure from closure area, by a new method of termination of small diameter pipes (less than 30 mm).It is analyzed an interpreted the structure obtained under the influence of characteristically factors of sealing procedure by plastic deformation and thermodiffusion.

Keywords: microstructure, sealing area, plastic deformation, diffusion, copper.

1. Introduction

The superficial heat treatments with material supply are domains which interest a lot. The sealing method of metallic pipes has a great importance for the reliability of the parts, depending on the destination and working conditions. We specify as practical application case for protection of thermocouples, thermal resistances and sensitive elements into temperature and pressure regulators structure.

In case of covers sealed by frontal bonnet weld, it was observed that the running life is short, by reason of running conditions - high temperature/pressure, corrosive agents etc. This fact determined the conception of a new method of sealing the covers. The new method involves plastic deformation of the pipe, followed by an important rise of the temperature and at last, thermodifusion [1]. The new procedure increase the running time of covers and was applied at small diameters pipes made of copper Cu5 [2]

2. Experimental results

The metallographic analysis of structure has been conducted on copper pipes. The pipes were made of almost pure copper, Cu 5. In the following pictures, Figures 1, 2, 3, 4 and 5 are presented the most important aspects of the sealed zone. Figure 1 show the macrostructure of the welded pipe and the main zones were the microstructure has been investigated. Figures 2, 3, 4 and 5 focus on the previously selected zones.

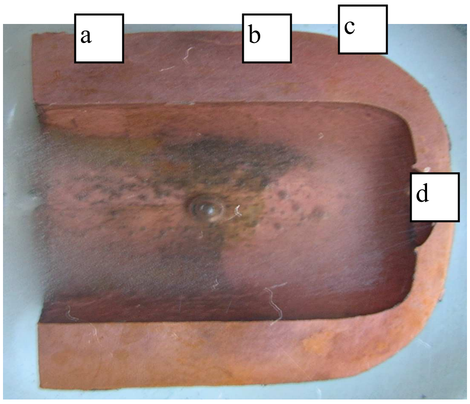
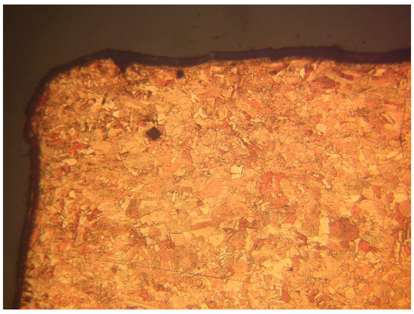
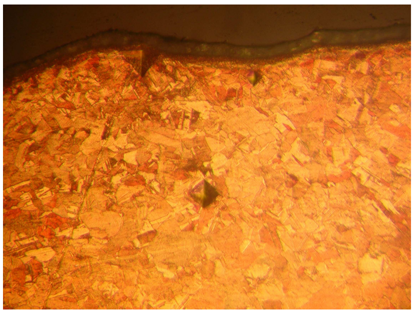


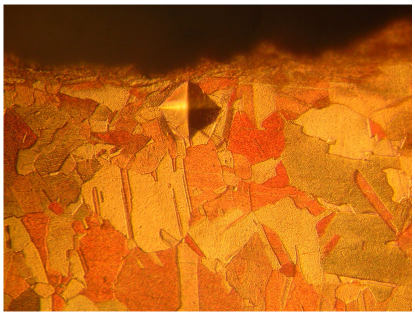
Figure 1. Macroscopic aspect of pipe made of copper Cu 5, welded by plastic deformation assisted by diffusion: a) unaffected area; b) middle area; c) deformation area; d) joint area.



a_1

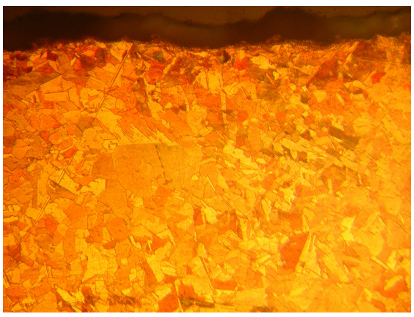


a_2

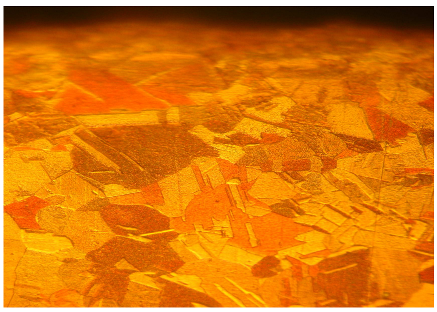


a_3

Figure 2. The microstructure of the plastic undistorted area., Polyhedric echiaxed grains of copper with twin crystals (a_1 – x 100; a_2 – x 250; a_3 – x 800).

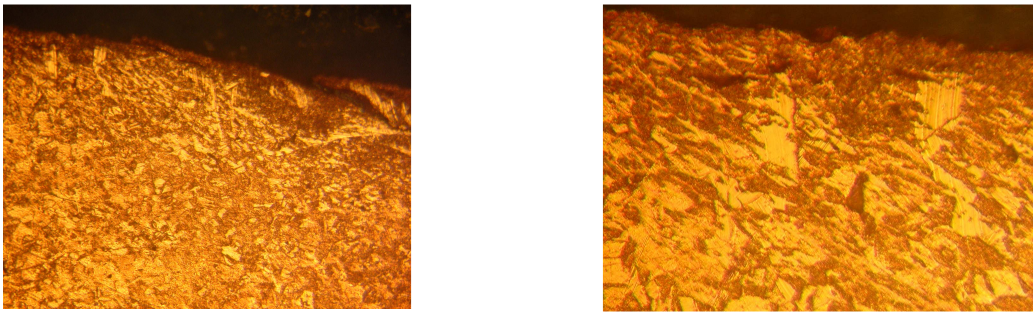


b_1



b_2

Figure 3. The microstructure from middle area plastic undistorted b, with polyedric twin crystals of copper undistorted(b_1 – x 250; b_2 – x 800).



c_1 c_2

Figure 4. The microstructure of plastic distorted area c, external hardened, with oblonged grains, outline trends (c_1 – x 250; c_2 – x 800).

d_1 d_2

***Fig.5.** The microstructure of the weld accomplished by plastic deformation assisted by diffusion d, with fine polyedric recrystallizated copper grains (d_1 – x250; d_2 – x800).*

3. The analysis's results and conclusions

The researches made in this work punctuate the following:

- the presence in the unprocessed areas (a, b) of a structure with polyedric grains of copper, containing some twin crystals and very rare and small spheroidals islands of copper oxide (Cu_2O_3);
- the presence in the plastic distorted areas (aisle at spherical head area) of a stress hardened structure with oblong grains, outline trends;
- the presence in sealing area obtained by plastic deformation assisted by diffusion of a structure with recrystallized fine grains.

The analysis of macrostructure and microstructure of the sealing area associate with sealing and reliability experimental and exploitation tests, we can conclude that this procedure is superior than the procedure where the covers are sealed by frontal bonnets welded in inert gas (argon).

Received November 22, 2008

**Secondary School "Unirea" Paşcani*
***Technical University "Gh. Asachi" Iaşi*

REFERENCES

1. Ridiche D., Calancia Ov., Sârbu I., **The preliminary study for a procedure to close small diameter pipes by difusion welding**, Bul. Inst. Polithn., Iaşi, Tom. LIV(LVIII), Fasc.1-3, 2008. pp. 61-64, Secţia Construcţii de Maşini, 12th International Conference – TMCR - 2008.
2. Ridiche D., Dima A., Calancia Ov., Sârbu I., **Experimental researches of packing by plastic deformation at high temperature and diffusion welding applied to the pipes of small diameters from some metallic materials**, Bul. Inst. Polithn., Iaşi, Tom. LIV(LVIII), Fasc.1-3, 2008. pp. 65-70, Secţia Construcţii de Maşini, 12th International Conference – TMCR - 2008.
3. Ridiche D., **Tehnologia pentru închiderea ţevilor fără sudare prin topire sau lipire**, Norma de fabrică Nr. 88/1989, I.T.R.D Paşcani, pp. 1-5.

ANALIZA METALOGRAFICĂ A STRUCTURII DIN ZONA DE ETANŞARE PRIN DEFORMARE PLASTICĂ ŞI DIFUZIE, LA ŢEVI CU DIAMETER MICI DIN CUPRU Cu5

Rezumat: Lucrarea prezintă macrostructura şi microstructura din zona de etanşare printr-o metodă nouă a capetelor ţevilor metalice cu diametre mici (<30mm), realizate din cupru Cu5. Este realizată şi interpretată structura obţinută sub influenţa factorilor caracteristici de închidere a ţevilor la sudarea prin deformare plastică asistată de difuzie.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

THE METALOGRAPHIC ANALYSIS OF STRUCTURE FROM SEALING AREA OBTAINED FROM PLASTIC DEFORMATION AND DIFFUSION ON SMALL DIAMETERS PIPES MADE OF UNALLOYED STEEL OLT35

BY

***DAN RIDICHE, **OVIDIU CALANCIA, **ADRIAN DIMA, **GAVRILĂ BOGDAN-LUCIAN**

Abstract: This work presents the microstructure and macrostructure from the closure area, obtained through a new method of termination of small diameter pipes (less than 30 mm).It is analyzed and interpreted the structure obtained under the influence of the main parameters of sealing procedure by plastic deformation and thermodiffusion.

Keywords: microstructure, sealing area, plastic deformation, diffusion, unalloyed steel..

1. Introduction

The sealing method of metallic pipes has a great importance for their reliability, depending on the destination and working conditions. We are mentioning as practical application of the method the protection covers of thermocouples, thermal resistances and sensitive elements from the structure of the temperature and pressure regulators.

In case of covers sealed with frontal bonnets cast welded, it was observed the running life is short, by reason of running conditions-high temperature/pressure, corrosive agents etc. This fact determined the conception of a new method of sealing covers, realized by plastic deformation at high temperature and thermodiffusion [1]. The new procedure increase the running time of covers and was applied at small diameters pipes made from unalloyed steel OLT 35 [2].

2. Experimental results

The metallographic analysis of structure has been conducted on cast steel pipes. The pipes were made of unalloyed steel, OLT 35 grade. In the following pictures, Figures 1, 2, 3, 4 and 5 are presented the most important aspects of the sealed zone. Figure 1 show the macrostructure of the welded pipe and are pointed the main zones were the microstructure has been investigated. Figures 2, 3, 4 and 5 focus on the previously selected zones.

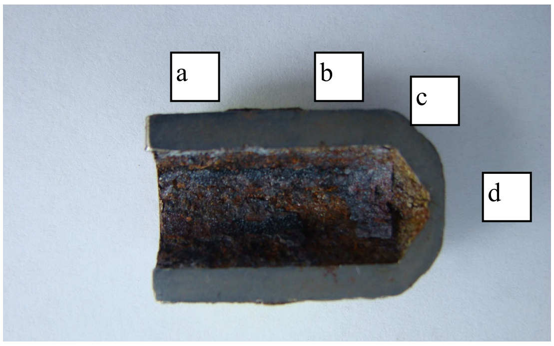
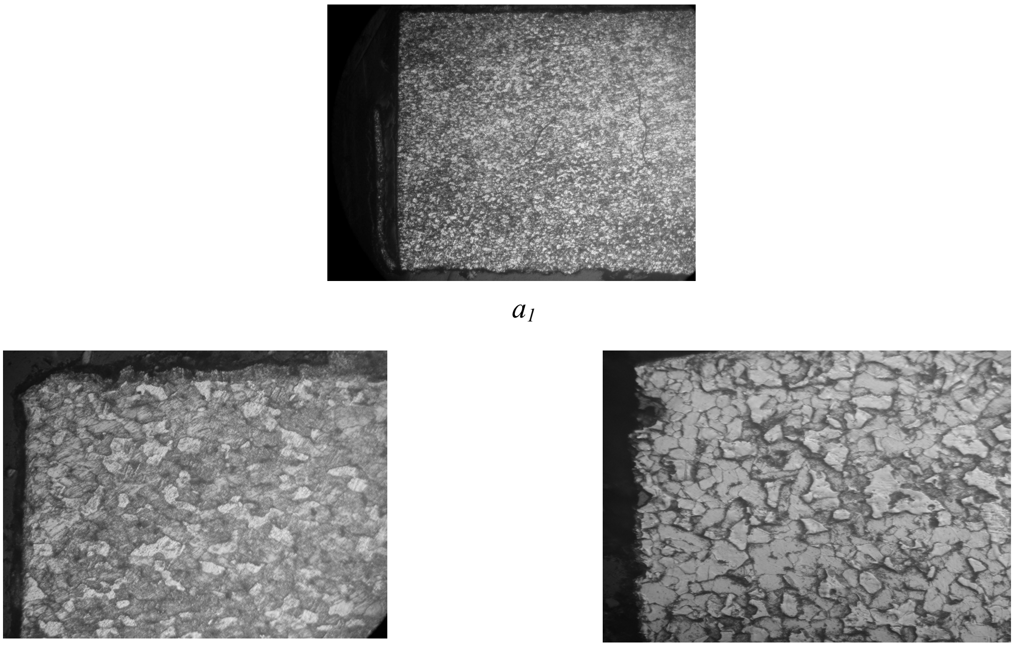


Figure 1. Macroscopic aspect of pipe made from unalloyed steel OLT 35 welded by plastic deformation assisted by diffusion: a) unprocessed area; b) middle area; c) deformation area; d) joint area.



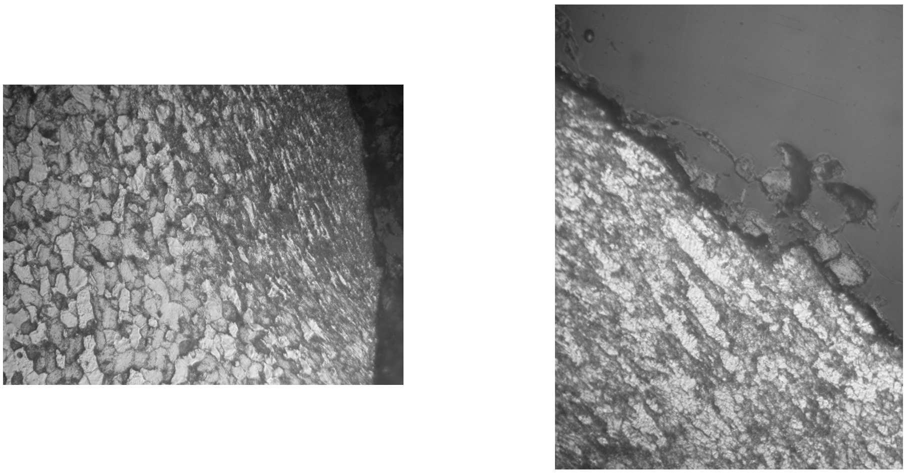
a_1

a_2 a_3

Figure 2. The microstructure of the plastic undistorted area a, ferito-pearlitic structure with polyedric grains undistorted (a_1 – x 100; a_2 – x 250; a_3 – x 800).

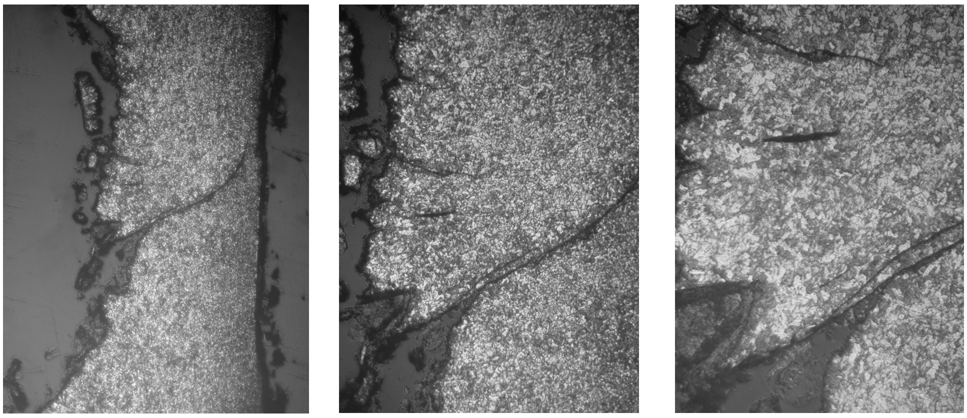
b_1 b_2

Figure 3. The microstructure from middle area b, plastic undistorted ferito-perlitic with polyedric grains undistorted (b_1 – x 250; b_2 – x 800).



c_1 c_2

Figure 4. The microstructure of plastic distorted area c, external hardened, with oblonged grains, outline trends (c_1 – x 250; c_2 – x 800).



d_1 d_2 d_3

Figure 5. The microstructure of the weld accomplished by plastic deformation assisted by diffusion d, ferito-perlitic with recrystallizated grains and with obvious cracks (d_1 – x 100; d_2 – x 250; d_3 – x 800).

3. The analysis's results and conclusions

The researches made in this work punctuated the follows:

- the presence in the unprocessed areas (a, b) of a ferito-pearlitic structure with polygonal grains;

- the presence in the plastic distorted areas (aisle at spherical head area) c, of a ferito-pearlitic structure, external hardened with oblong grains, outline trends;

- the presence in sealing area closed by plastic deformation assisted by diffusion d, of a ferito-pearlitic structure with recrystallized fine grains (the sample utilized for structural analysis from this area was chosen especially with micro cracks for accentuate the observance of optimal values of specific parameters agreed by experimental program [2].

After the analysis of macrostructure and microstructure of sealing area associate with sealing and reliability tests in exploitation [3], we can conclude this procedure is superior than the procedure where the covers are sealed by frontal bonnets cast welded.

Received November 10, 2008

**Secondary School "Unirea" Paşcani*
***Technical University "Gh. Asachi" Iaşi*

REFERENCES

1. Ridiche D., Calancia Ov., Sârbu I., **The preliminary study for a procedure to close small diameter pipes by difusion welding**, Bul. Inst. Polithn., Iaşi, Tom. LIV(LVIII), Fasc.1-3, 2008. pp. 61-64, Secţia Construcţii de Maşini, 12th International Conference – TMCR - 2008.
2. Ridiche D., Dima A., Calancia Ov., Sârbu I., **Experimental researches of packing by plastic deformation at high temperature and diffusion welding applied to the pipes of small diameters from some metallic materials**, Bul. Inst. Polithn., Iaşi, Tom. LIV(LVIII), Fasc.1-3, 2008. pp. 65-70, Secţia Construcţii de Maşini, 12th International Conference – TMCR - 2008.
3. Ridiche D., **Tehnologia pentru închiderea ţevilor fără sudare prin topire sau lipire**, Norma de fabrică Nr. 88/1989, I.T.R.D Paşcani, pp. 1-5.

ANALIZA METALOGRAFICĂ A STRUCTURII DIN ZONA DE ETANŞARE PRIN DEFORMARE PLASTICĂ ŞI DIFUZIE, LA ŢEVI CU DIAMETER MICI DIN OŢEL NEALIAT OLT35

Rezumat: Lucrarea prezintă macrostructura şi microstructura din zona de etanşare printr-o metodă nouă a capetelor ţevilor metalice cu diametre mici (<30mm), realizate din oţel nealiat OLT35. Este realizată şi interpretată structura obţinută sub influenţa factorilor caracteristici de închidere a ţevilor la sudarea prin deformare plastică asistată de difuzie.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

NEW ASPECTS CONCERNING THE UTILIZATION OF THE ENERGETIC SEPARATION EFFECT FOR MEN AND APPARATUS THERMAL PROTECTION

BY

***IOAN RUSU, **IURI BURENNIKOV and ***ION POPESCU**

Abstract: The paper presents the results obtained by the author concerning the researching, designing and achieving of an apparatus that use the energetic separation effect and which can be used directly in high temperatures environments. The achieved apparatus can be used for the cooling of the electronic command and control equipment as well as for the conditioning of the protection equipment of the human personnel.

Keywords: energy separation effect, cooling and protection equipment, vortex tube.

1. Introduction

The vortex effect of energy separation has as basis a very complex gasodynamic process that develops into a spatially swirled flow of viscous compressible fluid (1, 2). This effect consists in: by introduction inside of a cylindrical or conical space of a compressed and strongly swirled gas, from the resulted vortex there will develop two gas flows that have different senses of flowing (Figure 1). The formed flows have different temperatures by comparison with the supplying gas temperature: the cold flow has a less temperature (Tr < Ti) and the hot flow a bigger one (Tc > Ti).

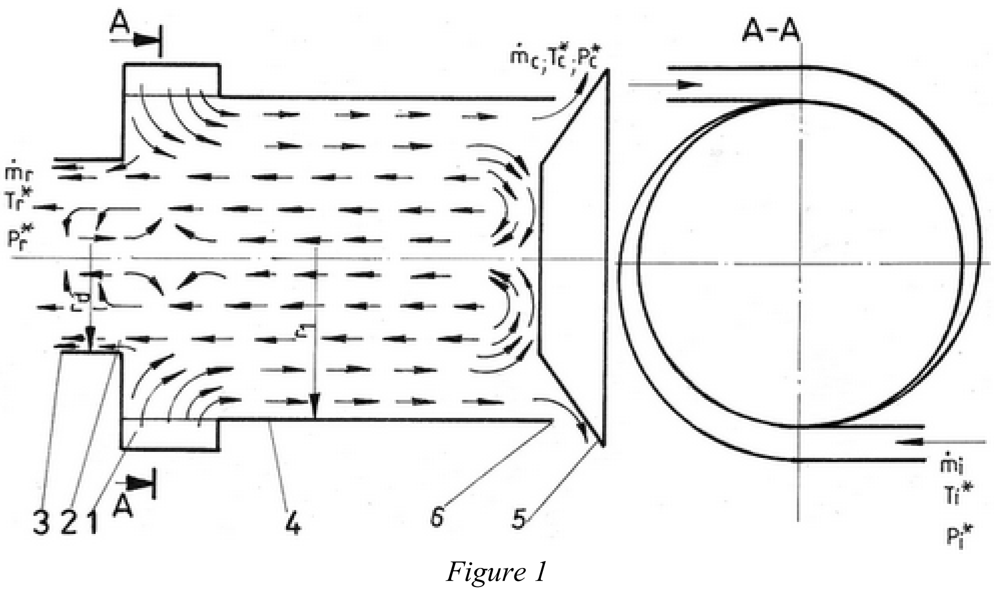


Figure 1

The energetic separation process in a viscous compressible fluid having a translatio-rotation motion involves important losses during the detention (irreversible process), fact that leads to an energetic efficiency lower than in the case of classical frigorific equipment. The practical utilization of vortex tubes can be done when the disadvantage linked to the big losses during operation, due to their low efficiency is not significant by rapport with their advantages: construction, operation and simple maintenance (no moving parts); reliability; compactness and reduced sizes; low inertia at working regime changes; rapid connection and start up as well as rapid shot down of the vortex tube; the possibility of simultaneous achieving of cooling and warming, cooling-vacuuming, separation of cooling stages; possibility of using pressures between 10 ÷ 106 Pa; wide range of inlet flow rates (from fractions to thousands cube meters by hour); low prices, etc.

2. Aspects of the theoretical research

The author consider (3) that for solving the problem of designing the apparatus that uses the mentioned effect (vortex tube) it is necessary a thermodynamic analysis of the process involved. On the basis of its results there have been achieved a physico-mathematical model of separation effect, taking into account the processes that occurs in the vortex tube: heat and mechanical work transfer between the axial layers and the peripheral ones; the pressure diminishing due to hydraulic resistances; the cooling of axial layers begins from the total temperature of the hot gas flow.

The model made possible the designing of a calculus program by means of which the optimum sizes of the vortex tube could be determined for some given data (temperature, pressure, speed and humidity of compressed gas, as well as the pressure and the flowing rate of the cold gas).

The comparison of the data from the literature with the calculated values have revealed a very low difference (under 4 %), fact that leads to the conclusion that the respective program can be used for designing of these apparatus without the verifying experiment.

3. The experimental research

There are different fields of activity (metallurgy, chemistry, fire fighting, etc.) in which working conditions at high temperature and/or in an environment with dust, toxical gases, etc. can not be avoid. The workers will be forced to wear protection equipment (masks, thermo-insulating suites). Mobil conditioning equipment is used for ensuring fresh air necessary for breathing as well as for ventilating the space between the human body and the suite.

Vortex tubes can be used for the above purpose by diminishing or enhancing of inlet air temperature. As a consequence, the flowing rate and the thermodynamical parameters of supplying air will depend on biomedical needs; so, on one hand it is necessary the evacuation from the disposable volume of the heat and vapor of sweat, and on the other hand the possibility of occurring some big differences of temperature between various parts of the human body. In the cooling regime, the inside temperature can be adjusted by mixing the cold flow with a part of the hot one, the remainders being evacuated in atmosphere. Of course, in the heating regime, the hot air flow is mixed with a part of the cold one. At the designing of the mobil conditioning equipment we take into account also the possibility of adjusting the working regime as a function of worker state, work difficulty and thermal regime of the environment.

In the supplying conditions descripted above, the thermal protection of the operator can be achieved by means of "conditioning wear" (Figure 2) or protection suite (Figure 3).

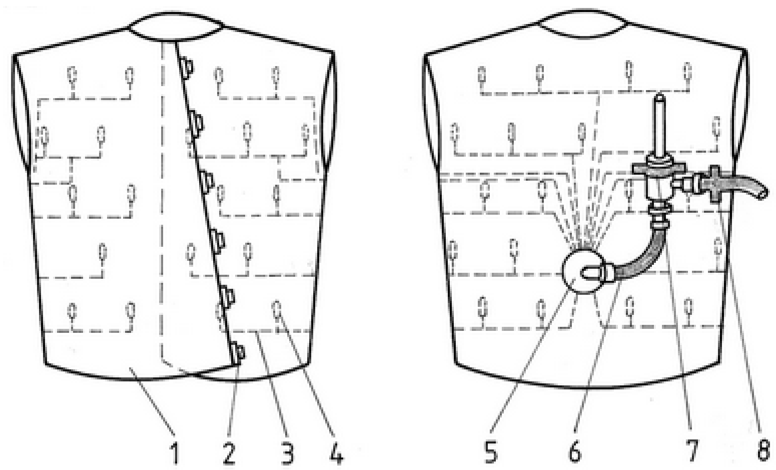


Figure 2

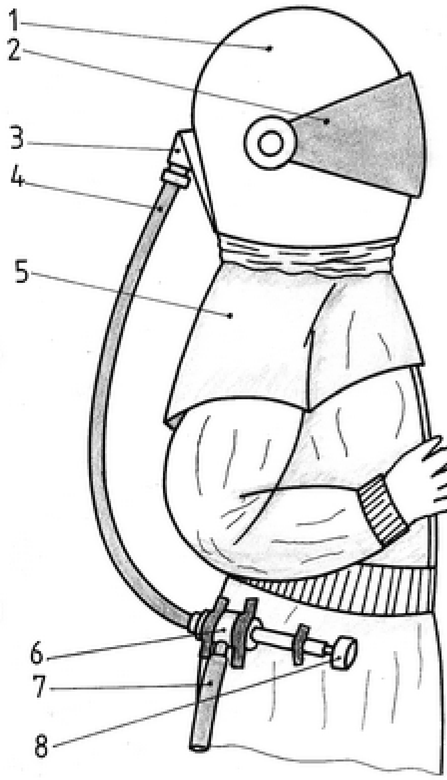


Figure 3

In case of "waistcoats" the protection suit is being replaced by an air cushion of desired temperature formed in closed proximity of the operator body. In the Figure 2: 1- thermoinsulated waistcoat; 2- adjustable tieing system; 3- ducts for the conditioned air circulation;4- outlet nozzles for conditional air; 5- distributor; 6- flexible connection link; 7- vortex tube; 8- flexible connection to compressed air. There can be seen that the vortex tube is attached on the waist-coat by means of a belt, being coupled on the cold side with the distributor; from these one starts channels to the nozzle type outlets of the waistcoat.

The thermal protection suit is endowed with a cap for protection against blows. In Figure 3: 1- cap; 2- eye hole; 3-cold air distributor; 4- flexible coupling for conditioned air; 5- protection suit; 6- vortex tube; 7-flexible coupling to compressed air supplying; 8-adjustment valve. The vortex tube delivers cold air inside a distributor placed in the suit's cap; from it a part of the air flow wash the had and the neck of the operator, another part cooling his body. The temperature of the "air cushion" can be easily adjusted by means of a valve placed on the left side of the suit.

If the distance of displacement of the operator is big , than, there exist the possibility of using of autonomous conditioning vortex installations, when the conditioned air supplying is achieved by means of a pressurized portable tank.

For diminishing the weight of the conditioning equipment and growing the cooling efficiency we endow the vortex device with an ejector which function is to make the air recirculation more intense and to achieve a temperature uniformisation inside the suit at optimum values from medical point of view.

By means of the achieved program the main sized (diameters, length) of the thermal protection suits vortex tube have been determined: r_1 = 0.0045 m, LT = 0.145 m, r_d = 0.0014 m.

Preliminary experiments done with this type of equipment were successful, the vortex tube being able to achieve an efficient thermal protection.

Nomenclature

LT - length of vortex tube; r_1 - vortex tube radius; r_d - diaphragm radius; m - flow rate; T - static temperature; T* - total temperature; p* - total pressure

Indices: i - inlet; r - cold; c - hot.

Received October 29, 2008

**Technical University "Gh. Asachi" Iaşi*
*** Vinnytsia National Technical University, Ukraine*
****ITM Suceava*

REFERENCES

1. Deissler R G, Perlmutter M, Int.J. Heat Mass Transfer 1 (1960) 173
2. Merkulov A P, **Vihrevoj effect i ego premenenie v tehnike**, Masinostroenie (Moskva), 1969
3. Metenin V I, Izv.vuz.-Av. Tehnika 2 (1972) 175
4. Tanaka M, Kida S, Phys.Fluids & Fluid Dyn. 9 (1993) 2079

UTILIZAREA EFECTULUI DE SEPARARE ENERGETICĂ PENTRU PROTECȚIA PERSONALULUI ŞI ECHIPAMENTELOR

Rezumat: Lucrarea prezintă rezultatele obținute de autor în cercetarea, design-ul şi realizarea unor aparate care să utilizeze efectul de separare energetică în medii de temperatură înaltă. Aparatele proiectate pot fi folosite pentru răcirea componentelor echipamentelor de comandă şi control cât şi pentru condiționarea echipamentului personalului.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

CONTACT MELTING OF UNALLOED STEEL WITH GRAPHITE IN DIFFUSIVE UNSTATIONARY MODE

BY

VALERY SAVULYAK, ANDRY OSSADCHUK, VIKTOR SAVULYAK

Abstract: In the article an analytical model and result simulation of process the contact melting is considered in the system unalloy steel – graphite. It is shown that speed of growth of liquid phase is the function temperature the contact melting and maintenance of carbon in steel.

Keywords: contact melting, diffusive unstationary mode, Fick laws.

1. Introduction

In the Vinnitca national technical university there are created technologies which allow to get compositions materialy type steel is white cast-iron [1,2]. High tribotechnition descriptions have such compositions. [1,2]. Essence of this phenomenon consists in the origin of liquid phase in the point of contact of two hard matters which make the system with evtektikoy, at heating of them to the temperature, what more low temperatures of melting of these matters.

Works which would explore the parameters of the contact melting numeral, not so much, in a feature for components with the high temperature of evtektichnogo transformation. In part of these works the process of the contact melting is explored in the stationary mode (on condition that a liquid layer in the place of contact has a permanent size due to the permanent taking of liquid phase external effort of clench of bodies which take part in the contact melting) [3]. At formation of liquid phase in researches [1, 2] a thickness of liquid layer was not a permanent size. This layer is multiplied in course of time as a result of dissolution in the liquid phase of contacting with her hard phases to complete dissolution of one of these hard phases (unstationary process). Exactly such process is explored in works [4, 5] the authors of which for speed of the contact melting bring speed of movement in the liquid of point along with an evtektichnoy concentration. Possibility to watch after the movement of fronts of division between a liquid and hard phases which plavlyat'sya disappears on such conditions. By us for basis of construction of mathematical model of the contact melting of steel with a graphite the model of the contact melting is accepted for the unstationary diffusive mode between a graphite and iron [6].

Contact melting of steel with a graphite it is possible to present as a diffusive transfer of carbon from a graphite through a liquid in austenit. In literary sources and until now there is information, that a graphite can be in an equilibrium from tsementitom and the contact melting of iron with a graphite takes place through an intermediate phase - Fe_3C [7]. But it is impossible. Equilibrium between a graphite and tsementitom is impossible in the system of Fe - C, and also in the systems of Fe - C - alloying an element, in which the last promotes the coefficient of activity of carbon (for example silicon). Such equilibrium is possible only in a triple alloy in which alloying an element reduces the coefficient of activity of carbon (for example, under act of manganese, chrome, vanadium) [8, 9].

2. Theoretical considerations

At the construction of model consider that steel does not contain no chemical elements except for iron and carbon. That is why for the construction of mathematical model use the diagram of the state Fe-C (Fig. 1) [9, 10, 11]. It is known that in solubility of iron in a graphite very had [12], that is why will ignore her.

For description of dependence of solubility of carbon in austeniti and liquid as a function of temperature mathematical dependences, got in work, are used [6].

Austenitniy of solidus - in the form of line which passes through two points I and C:

$$c_1 = \frac{5,4572814 - 3,0299343 \cdot 10^{-3} \cdot T}{16,294585 - 2,378282871 \cdot 10^{-3} \cdot T} \tag{1}$$

where T - is a temperature in K.

Dependence of concentration of austenitnogo likvidusu:

$$c_2 = \frac{-7,252632 \cdot 10^{-6} \cdot T^2 + 1,6932364 \cdot 10^{-2} \cdot T - 6,9699775}{-5,6928103 \cdot 10^{-6} \cdot T^2 + 1,3290725 \cdot 10^{-2} \cdot T + 6,540054} \tag{2}$$

Graphite likvidus is beautifully described a line c3 = 1,35 + 2,50·10-3·t, (in gw.%), but it is just for the out-of-date variant of diagram Fe - C (graphite) [13]. Abandoning the toy angle of slope of line in relation to the axis of temperature bring to conformity the modern picture of diagram [10, 11, 12], and replacing the first element, will get dependence in atomic stakes:

$$c_3 = \frac{4,3141808 \cdot 10^{-1} + 1,396175 \cdot 10^{-3} \cdot T}{12,349633 + 1,0959 \cdot 10^{-3} \cdot T}. \tag{3}$$

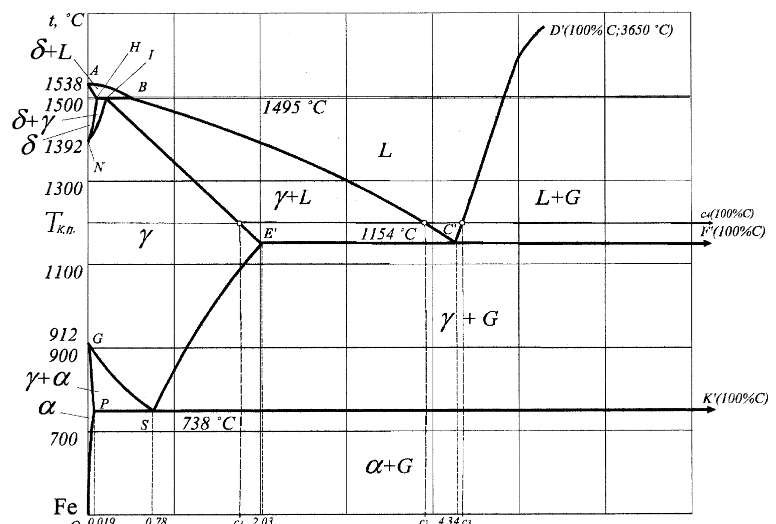


Figure 1. Diagram of Fe-C (Graphite)

Dependences are resulted intended for the design of process of the contact melting between a graphite and γ -solide solution of carbon in iron in all interval of temperatures, when it is possible (1154-1499 oC).

Will depict on the resulted diagram (Fig. 1) of konodu, which answers the temperature of the contact melting (Tkm.). Description of process will adopt the followings denotations: c_{Fe}^{C} - it is a concentration of iron in a graphite; c_{C}^{Fe} - it is a concentration of carbon in austenite; c_{Fe} - it is a concentration of iron in austeniti; cC - is a concentration of carbon in a graphite; c_{Fe}^{L} - it is a concentration of iron in a liquid; D_C - it is a coefficient of diffusion of carbon in austeniti; D - it is a coefficient of mutual diffusion in a liquid.

Sizes of concentration of components in all three phases must satisfy identities:

$$c_{Fe} + c_{C}^{Fe} \equiv 1;\; c_C \equiv 1;\; c_{Fe}^{C} \equiv c_0;\; c_{Fe}^{L} + c_{C}^{L} \equiv 1. \tag{4}$$

Farther will ignore a difference between the total volume of molten components and volume of liquid phase and influencing of thermal effects on the processes of diffusion.

For the design of the contact melting will represent his chart (Fig. 2), where for beginning of coordinates the initial border of division of phases of Austenite and graphite is taken [9].

Division of concentration of carbon in austeniti or liquid it is possible to define by the second of Fiks law:

$$\frac{\partial c(x,\tau)}{\partial \tau} = D \cdot \frac{\partial^2 c(x,\tau)}{\partial x^2}, \tag{5}$$

where c(x, τ) - it is a concentration; D - it is a coefficient of diffusion.

For simplification of task ignore dependence of coefficient of diffusion on a concentration.

Will apply the known substitution of Boltsmana:

$$\lambda(c) = \frac{x}{\sqrt{\tau}}, \tag{6}$$

then, taking into account equalities

$$\frac{\partial c}{\partial \tau} = \frac{dc}{d\lambda} \cdot \frac{\partial \lambda}{\partial \tau} = -\frac{dc}{d\lambda} \cdot \frac{x}{2\tau^{3/2}}, \tag{7}$$

$$\frac{\partial^2 c}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial c}{\partial x}\right) = \frac{\partial}{\partial x}\left(\frac{dc}{d\lambda} \cdot \frac{\partial \lambda}{\partial x}\right) = \frac{\partial}{\partial x}\left(\frac{dc}{d\lambda} \cdot \frac{1}{\sqrt{\tau}}\right) = \frac{d^2 c}{d\lambda^2} \cdot \frac{1}{\tau}, \tag{8}$$

differential equalization in (5) parts grows into ordinary differential equalization

$$\frac{d^2 c}{d\lambda^2} + \frac{\lambda}{2D} \cdot \frac{dc}{d\lambda} = 0. \tag{9}$$

Will search the decision of equalization (5) in a kind

$$c(x,\tau) = \bar{a} + \bar{b} \cdot \hat{O}\left(\frac{x}{2 \cdot \sqrt{D \cdot \tau}}\right), \tag{10}$$

where $\bar{a}$ i $\bar{b}$ - to constant, which are determined from regional terms; the function of errors of F(z) is evened

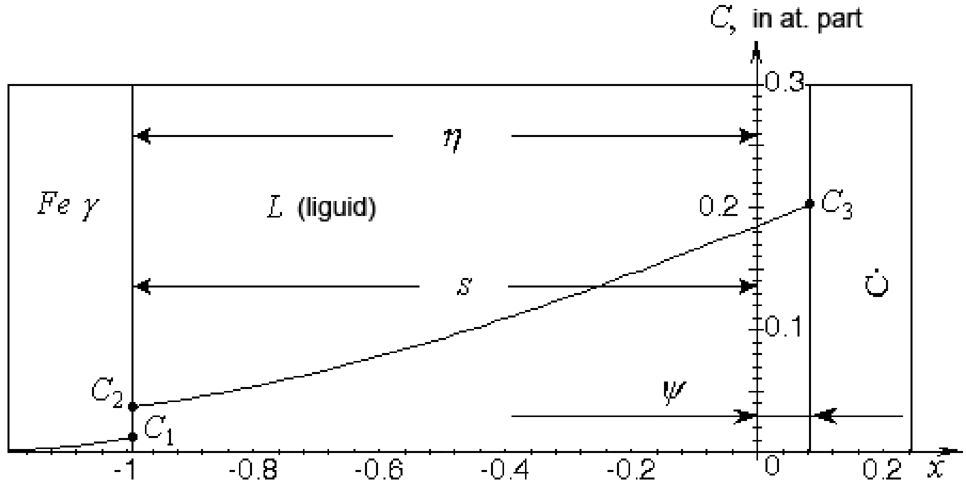


Figure 2. A chart of process of the contact melting and division of concentration of carbon is in phases: Feγ, L (liquid), C (grafite).

$$\hat{O}(z)=\frac{2}{\sqrt{\pi}}\cdot\int_0^z e^{-\theta^2}d\theta. \qquad (11)$$

Thus division of concentrations accordingly in austeniti and liquid:

$$c(x,\tau) = c_C^{Fe} = 1 - a + b\cdot\Phi\left(\frac{x}{2\cdot\sqrt{D_C\cdot\tau}}\right), \quad D = DC,\ -\infty \le x \le -\eta \qquad (12)$$

$$c(x,\tau)= c_C^{L} = a_1 + b_1\cdot\Phi\left(\frac{x}{2\cdot\sqrt{D\cdot\tau}}\right), \ -\eta \le x \le \psi \qquad (13)$$

On the scopes of section of phases of x=ψ and x=-η have permanent values of concentrations regardless of time. With an account (12), (13), it is possible only after a condition, that law of movement of scopes between iron and liquid and between a graphite and liquid accordingly described equalizations:

$$\psi = 2\beta\sqrt{\tau} \qquad (14)$$

$$\eta = 2\alpha\sqrt{\tau} \qquad (15)$$

where α, β - constants which need to be defined.

From a boundary condition

$$c_C^{Fe}\Big|_{x=-\infty} = c_0 \qquad (16)$$

where c_0 – a table of contents of carbon is in steel, with an account (12), (4) and equalizations of Φ(-x)=-Φ(x), Φ(∞)=1, we have

$$a + b = 1 \qquad (17)$$

From a boundary condition

$$c_C^{Fe}\Big|_{x=-\eta} = c_1, \qquad (18)$$

with an account (12) and equalizations (15), swims out

$$a + b\cdot\hat{O}\left(\frac{\alpha}{\sqrt{D_C}}\right) = 1 - c_1 - c_0. \qquad (19)$$

By the decision of the system of two linear equalizations (17), (19) will get

$$a = \frac{1 - c_1 - \hat{O}\left(\frac{\alpha}{\sqrt{D_C}}\right)}{1 - \hat{O}\left(\frac{\alpha}{\sqrt{D_C}}\right)}. \tag{20}$$

$$b = \frac{c_1}{1 - \hat{O}\left(\frac{\alpha}{\sqrt{D_C}}\right)}. \tag{21}$$

By analogy, taking into account boundary terms for a liquid phase

$$\left. c_C^L \right|_{x=-\eta} = c_2, \qquad \left. c_C^L \right|_{x=\psi} = c_3. \tag{22}$$

and equalizations (13)*(15) will have

$$a_1 = \frac{c_2\hat{O}\left(\frac{\beta}{\sqrt{D}}\right) + c_3\hat{O}\left(\frac{\alpha}{\sqrt{D}}\right)}{\hat{O}\left(\frac{\alpha}{\sqrt{D}}\right) + \hat{O}\left(\frac{\beta}{\sqrt{D}}\right)}, \tag{23}$$

$$b_1 = \frac{c_3 - c_2}{\hat{O}\left(\frac{\alpha}{\sqrt{D}}\right) + \hat{O}\left(\frac{\beta}{\sqrt{D}}\right)}. \tag{24}$$

For finding of values of coefficients α and β will write down terms on mobile scopes

$$n^L \cdot D \cdot \left.\frac{\partial c_C^L}{\partial x}\right|_{x=-\eta} + n^{Fe} \cdot D_C \cdot \left.\frac{\partial c_C^{Fe}}{\partial x}\right|_{x=-\eta} = n^{Fe} \cdot \frac{d\eta}{d\tau} \cdot \left(c_2 - c_1\right), \tag{25}$$

$$n^L \cdot D \cdot \left.\frac{\partial c_C^L}{\partial x}\right|_{x=\psi} = n^C \cdot \frac{d\psi}{d\tau} \cdot \left(1 - c_3\right), \tag{26}$$

where nFe, nC, nL - an amount of particles is in unit of volume of the proper phase.

Taking into account equalizations of type

$$\left.\frac{\partial c_C^L}{\partial x}\right|_{x=-\eta=-2\cdot\alpha\cdot\sqrt{\tau}} = \frac{-b_1}{\sqrt{\pi \cdot D \cdot \tau}} \cdot e^{-\frac{\alpha^2}{D}}; \quad \left.\frac{\partial c_C^{Fe}}{\partial x}\right|_{x=-\eta=-2\cdot\alpha\cdot\sqrt{\tau}} = \frac{-b}{\sqrt{\pi \cdot D_C \cdot \tau}} \cdot e^{-\frac{\alpha^2}{D_C}}. \tag{27}$$

but correlations (21), (24) equalization (25), (26) acquire the type of the system of two nonlinear equalizations

$$\sqrt{\frac{D}{\pi}} \cdot n^L \cdot \frac{c_3 - c_2}{\hat{O}\left(\frac{\alpha}{\sqrt{D}}\right) + \hat{O}\left(\frac{\beta}{\sqrt{D}}\right)} \cdot e^{-\frac{\alpha^2}{D}} - \sqrt{\frac{D_C}{\pi}} \cdot n^{Fe} \cdot \frac{c_1 + c_0}{1 - \hat{O}\left(\frac{\alpha}{\sqrt{D_C}}\right)} \cdot e^{-\frac{\alpha^2}{D_C}} = n^{Fe} \cdot \alpha \cdot \left(c_2 - c_1\right), \tag{28}$$

$$\sqrt{\frac{D}{\pi}} \cdot n^L \cdot \frac{c_3 - c_2}{\hat{O}\left(\frac{\alpha}{\sqrt{D}}\right) + \hat{O}\left(\frac{\beta}{\sqrt{D}}\right)} \cdot e^{-\frac{\beta^2}{D}} = n^C \cdot \beta \cdot \left(1 - c_3\right). \tag{29}$$

The system of nonlinear equalizations (28) is got, (29) enables only numeral decision. The numeral decision of this system enables to define the tabular set functions of coefficients vid the temperature of the contact melting and maintenance of carbon in steel α=α(T,c0), β=β(T,c0). It was realized by the mathematical package of Maple V R6. Tabular information, achievements in the mathematical package of Maple V R6 it was passed in the spreadsheets of Excel for next approximation.

Received November 17, 2008 *Vinnytsia National Technical University, Ukraine*

REFERENCES

1. Zhukov A. A., Bondarenko A. V., Ossadchuk A. Yu. **New Methods of Joining Carbonaceous Materials to the Surface of Steel**.// Joining sciences. vol.1, № 4, 1993. P. 188 - 193.
2. Сывынюк В. Г., Жуков А. А., Заречный А. М. **Электроконтактное легирование поверхностей стальных деталей волокнистым углеродным материалом**. // Сварочное производство, 1987. № 4 - С. 11 - 14.
3. Гетажеев К. А., Савинцев П. А. **К расчету скорости контактного плавления**. // Физическая химия поверхностных явлений при высоких температурах. Киев: Наукова думка, - 1972. - С.194-196.
4. Пашечко М. И., Голубец В. М. **Способ получения эвтектических термодиффузионно-наплавленных покрытий**. // МИТОМ. - 1989. - № 6 - С. 26 - 30.
5. Пашечко М.И., Голубец В.М., Чернец М.В. **Формирование и фрикционная стойкость эвтектических покрытий**. - К.: Наук. думка, 1993. - 343 с.
6. Михалевич В. М., Осадчук А. Ю. **Визначення параметрів контактного плавлення заліза з графітом у дифузійному нестаціонарному режимі** // Вісник Вінницького політехнічного інституту, 2000, №4 (17), С. 55 – 61.
7. Лашко С. В., Лашко Н. Ф. **Пайка металлов**. - М.: Машиностроение, 1988. - 376с.
8. Zhukov A. A., // Metal Science and Heat Treatment (Moscow).-1988. №4. - P.2-9.
9. Zhukov A.A. **The System Fe-Fe$_3$C** // Foundry.-1997.- № 2. -P. 38-39.
10. Zhukov A. A., Ossadchuk A. Yu. **The iron-carbon phase diagram. New data and technologies**. In. Heat Treatment and technology of surface coatings. Materials of the MOTO - 7-th International Congress. Moscow. 1990. Vol. 2, p. 157 - 166.
11. Gustafson P. **A thermodinamic evaluation of Fe-C system**. // Scand. J. Met, 1985, 14, № 5, 259 - 267.
12. Вертман А. А., Самарин А. М.. **Свойства расплавов железа**. М.: Наука, 1966. - 280 с.
13. **Справочник по чугунному литью**. / Под ред. Н.Г. Гиршовича - 3-е изд перераб. и доп. - Л.: Машиностроение. Ленинградское отделение, 1978. - 758 с.

CONTACTUL LA TOPIRE, ÎN STARE DIFUZIVĂ NESTAȚIONARĂ, A OȚELULUI NEALIAT CU GRAFITUL

Rezumat: Lucrarea prezintă un model analitic şi rezultatele simulării procesului de contact al topiturii din oțel nealiat cu grafitul. Se arată că viteza de creştere din fază lichidă este funcție de temperatura contactului şi de timpul de menținere al carbonului în oțelul lichid.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

COMPARATIVE PRACTICES OF WORLDWIDE HUMAN RESOURCES MANAGEMENT IN MATERIAL SCIENCE

BY

CRISTINA MARIA STOICA

Abstract: The article deals with the human resources management within the framework of the new strategies of the multinational companies in material science, for search of a better competitiveness and flexibility. We will have in view exemplifying the researches regarding flexibility, as well as the new trends concerning worldwide human resources management, the outsourcing of certain activities and also of the staff that is realizing them.

Keywords: human management in material science.

1. Introduction

The development of the new information technology as well as communication technology made possible the real-time connection among all the money markets in the world. Gradually, the financial logic takes the place of the enterprise logic, imposing on the managers from all over the world to embrace new attitudes regarding the human resources management, to seek for means of swiftly replying to any unexpected menace of the environment.

Business combination, achieved through mergings that are more and more often, aims at gaining bigger and bigger market shares and realizing economies of scale; it allows the improvement of the security and of the stabilization of the financial results. The operations of business combination produce immediate costs, without having the profitableness certainty. We must specify that the mergings or the business combinations share a common feature, that is massive staff dismissal. It has been noticed a gradual transformation of the big enterprises into more and more specialized subsidiaries. Within them, it has been recorded an increase regarding the phenomenon of outsourcing, respectively the gradual entrusting towards the exterior of the enterprise of all those positions believed not to be fundamental.

The swift development of telecommunications allows the Swissair company to entrust accountancy department to an India based company, all the data being sent daily via Internet. The main advantage is that a Swiss accountant costs around 70.000 $ per year, while an Indian accountant – 3.000 $ per year. 1 The American group Sara Lee, in its vast plan of deverticalization, sold 9 of its 13 textile mills, for concentrating on creation and commercialization activities. In this case too, the labour force is directly aimed at. Even more, the European Trade Union Federation considers that it is more like a relocation in disguise. The main idea behind the outsourcing process is that of gradual replacement of the labour law with commercial law, which is more flexible and negotiable with different kinds of interlocutors: lawyers, trade-unionists or politicians. The outsourcing has as a main worth the removal of the operational responsibility regarding human resources management from the strategic decision centres and the division of the employees, reducing thus the risk of an uncontrolled social movement.

2. The development of the classic methods in human resources management around the world

Taking into account the overall development, the companies are anxious regarding the recruitment, being necessary sustained efforts from their part as to the skilled or over skilled personnel. There is a constant need for computer experts. North America and Europe are in direct competition. In almost all cases, the recruitment process is freely realized, on the basis of selection criteria that, for example, are forbidden in North America. The discrimination emerges especially regarding the genders, women being restricted to a limited number of positions, thus keeping them in unfavourable working conditions.

The possibilities offered by the faulty laws are maximally exploited. Thus, in Mexico, a company like Volkswagen has as superior managers only German employees. At Petrole Mexicanos (PEMEX), the trade-union decides upon the people that will be hired, except few positions, for which the management department reserves for itself the right to select. Even regarding the Mexican Public Functions, it happens to appear unusual situations. Thus, average and superior employees are part of the reliable teams, vertically integrated into the hierarchy. This situation results from the fact that by the end of the 6 year presidential mandate, the employees sign the resignation letter, enabling the newly chosen to reorganize their government apparatus. The greater part of the developing countries use exclusively the recuitment based upon recommendation, developing thus internal relationships of solidarity between the employees, but that allows them to become self-disciplined, because the one who recommended a person for employment, is in his turn responsible for that person, from the management point of view [1].

In North America, on the contrary, the concern is foreign employees oriented. For example, Ktron, the global leader in the production of high technology (feeding, fertilizers and plastic) has 2/3 of its staff foreign employees. The personnel recruited from outside the country, generates an important rivalry for the American personnel, because the companies don't dispose every time of necessary time to wait for their American employees to acquire the necessary experience.

Nowadays, the companies have on hand a wide international basis of available abilities, that answer with promptness to the company's expectations, without further additional investigations. We must specify that, in case the foreign employees succeeded in working in top management, within the American companies (especially the European companies), this happened only after a number of years of cultural immersion or after acquiring rich experience in international business [2].

3. The New Coercions Regarding Work and Dismissals

At present, the main trend is that of increasing degree of precariousness of the work place. We note that the rapid employment that used to take place before by a swift presentation of the job, after the notification of the salary, now the companies try to protect themselves better, coming with more precise and detailed contracts, containing more constraints for the future employees. Thus, in the developed countries, the fixed-term or part-time employment contracts gain grounds to the undefined ones. In France, 77% of the employees have a part time contract. This is the result of the increasing of the number of jobs, artificially created and sustained by the government, especially the solidarity employment contracts.

Even in Japan, where it has been demonstrated a particular solidarity within the social connections, employment and the life time employment contracts are being removed progressively, within the large companies occurring the dismissals. The dismissal of more than 1000 employees is justified by the problems that the company has, due to maintaining the old organization patterns . Matsushita, Toyota and Hitachi, that used to position themselves on the first places on the market, encountered difficulties generated by the lack of rapidity in adopting new decisions and in adapting them to the market [3]. In United Kingdom, it is used the Zero Hours Employment Contract, the companies having the right to not guarantee work hours to certain employees categories , compelling them to fill in temporary positions, when they are solicited by production needs, without being paid.

4. The Remuneration Policy Around the World

The French Company Gemplus records a spectacular increase and the number of the employees is in constant rise. The human resources department embraced the decision of assessment of the positions, but the quickness of the transformations made difficult this task and that is why it was chosen a classification system, which supposes assessing each person's contribution and not assessing every person's contribution.

Thus it have been identified the following roles: the professionals and senior professionals - assessed depending on their own performances; project leaders and senior project leader, that have an organizational and training part; managers and senior managers, having a decisional role, regarding the financial and human aspects. The employees, in their turn, are classified according to six types of contributions to the company: responsabilization, network and team work, improving the organization, innovation and customer orientation. During an interview of annual assessment, the chief must verify if his employee is in an acquisition stage, an orientation one or of transformation. If the employee is in the last stage, it is announced a promotion at a higher level in the organizational hierarchy [4]. The Siemens Company adopted an administration tool that includes the performance bonuses, based upon a new principle: the calculus of the variable part of the manager's salary, based upon his capacity of creating extra economic value for his company, profits generated in his department or in his company must cover the costs of the invested capital.

The Stock Companies establish the bonuses for their agents, starting from the net margin, having in view the amount of capitals. The Anglo-Saxon offices, specialized in payment of the employees matters (Hay, Towers Perrin, Hewitt), confirm the success of this method. Having as a fundament the profitableness of the invested capital, it arises the possibility of comparing the companies on a world scale, department by department. Thus it appears the possibility of identifying the companies that generate a maximum of added value, that are the most alluring on the investors' market, like retiring funds. We underline that we must attach great importance to financial logic, even regarding the human resources management.

In Japan, the level of economic growth determines a reorganization of the human resources management. The Japanes employers have at least graduated the high-school, starting at the basis of the hierarchy, with a salary level inferior to the average of the working employees, reaching the status of staff after 10-15 years. In order to stimulate the creativity, many of the Japanes companies decided to implement a new type of payment, called the performance salary.

After the salary determined by age, applied during 1950-1965, and the salary for competence (1965-1990), this system allows salary revision, in order to cut them (10%) , and for a better control of their level. This salary is annually updated and it is negociated by the employees and the managers, on the basis of a contract limited at one year , that can be renewed.

The staff's annually total wage is determined by evaluating individual performances. The wage is divided into 12 equal parts, plus a bonus. Measuring the performances has as a foundation the target administration. At each 6 months, every employee is interviewed by his chief, during which it will be assessed the results of the anterior semester, and establishing the future semestrial aims (quantitative: amount of sellings, the production level, improving the quality, needed time for realizing a project; and qualitative: leadership and the capacity of training the subalternates) [5].

5. Issues of training and qualifying the workforce

The studies show that the concept of comparative advantage has evolved. The cheap labour force is still needed, and is looked for by some companies, where ever it is. But a small salary isn't enough nowadays. In the future, the true problem will be finding qualified labour force, in sufficient quantity, because the majority of the undeveloped countries have difficulties in training properly their labour force. Additionally, there emerge great difficulties in maintaining the best employees against the rich Northern countries, that have strong policies for recruiting the southern elites, several doctoral programmes, that represent excellent recruiting and socialising systems for the future managers, for which their country paid their initial training.

The situation is even more complicated as in the former USSR countries, where multiple business opportunities are blocked due to the lack of reliable and apt labour force.

6. Ways of outsourcing different activities and the staff that is realizing them

Some companies progressively outsource important departments, like human resources management, entrusting them to specialized offices, that sometimes take over the staff to be outsourced, but on the basis of contracts. The biggest office in this area is Earnst and Young, that merged with KPMG, taking over 50% of the company specialized in this activity, Externance; another company is BPM- Business Process Management, branch of the Andersen Consulting company. An investigation that took place in USA, made by Boston Consulting Group, shows that 65% of the enterprises that have outsourced a great deal of their activities, are paying more than if they would have done it within the company [6].

Some distribution companies resort to a sophisticated type of supporting society; numerous employees, that lost their jobs, tend to survive autonomously, with intermittent contracts, paid under the form of fees. The companies hire this people, collecting the fees instead of them, in order to transform them into wages, after cashing bountiful commissions. In spite of this shortcoming, this method allows those who are interested still to maintain the status of employees, for the social advantage that result from here

Emerged in France, in 1952, the first temporary societies have been created in order to compensate for the absence, especially for the periods of maternity leave. In the 60 and 70, the enterprises started to appeal to these companies, this solution gradually becoming a possible way of recruitment, the agencies having difficulties in keeping the best temporary employees. But, starting from the ’90, the interim imposed itself as a privileged strategic tool of the flexibility. The industry is the main beneficiary of this tool, having a 55,3% percentage of temporary employees, while in France this sector represents only 27,7% of the jobs, 77% of these jobs with defined length aims at the category of workers.

In the car manufacturing industry, the interim has become an important method of recruiting the productive employees. It has become above all a flexibility tool, regarding the work management [7].

In this context, there emerge several important advantages: the temporary employees are paid with the national minimal wage, regardless the diplomas they’d earned; the temporary employees aren’t unionized, they must never fall ill.

In UK, this method has developed to the same extent; for example, in Buron company, that laid off 1000 employees, that had a legal employment contract, has substitute them for 3000 temporary employees. In Japan this practice has been systematized.

7. Relocation

The production relocation is a complex process, consisting in reengineering the whole production facilities, moving it abroad, to benefit from comparative advantages for all or just a part of the production. The main comparative advantage is that of low labour costs. An example with worldwide implications is that of sports footwear industry, that vanished from the developed countries, that are importing nowadays in order to cover the expenditure for this product category.

Creating free areas, tax exonerated, and offering production spaces, with a dirt cheap labour forces is a way of alluring the multinational companies. The work force is generally unskilled, precarious and low paid (75 cents/h in Togo, 85 cents in Maurice Island, 1,2 $ in Malaysia, 4$ in South Korea). Free areas are more and more numerous, being available over 250 in 70 countries [7].

In exchange, the pursuit of competitivity is intensified. Thus St Maurice Island succeeded in a strategic placement by subcontracting the textile manufacturing, the island not possessing the capacity of covering all the orders. In front of this problem, it has been adopted the resolution of relocating a part of the production facilities in Madagascar, where there can be done the most difficult tasks at low costs.

The moment the Taiwanese and Korean employees got a significant raise, Reebok and Nike shifted a great part of the production to Indonesia, China and Thailand. Nike aims at Vietnam and China, where the wages are lower than in Indonesia. For the unqualified people the chances to find a well-paid job diminished, especially in the ’90, when the economic globalization materialized into the relocation of a part of the work force.

In Canada, working at home spread rapidly, the wage depending on the number of products manufactured, the employees gaining less than the national minimum wage. The Canadian employees that work from home are situated in the informal activity field, that represents nowadays a second source of man power, due to the fact that this parallel economy achieves supplementary incomes, that in a large measure are tax exempted.

The concept of informal is considered by some experts to be a set of activities, regarded as legal. It is thought that the underground industry belongs to the informal field, that remains a disputable phenomenon in the rich countries, representing a way of solving some welfare issues, being spread all over the Third World countries. Today, there are a few hundred million people that work in enterprises, that are permanently on the verge of survival and that treat their staff accordingly. The omnipresence of the informal sector is strengthened by the less controllable migratory flux. Some of this people that migrate keep their old habits in their new countries too and are trying to reconstitute their habitual environment. The informal situation are getting more and more frequent within all the countries.

8. Child Labour

History shows that the abolition of child labour and establishing the compulsory education represented essential conditions for development in Europe and North America. In 1990, within the Convention on the Rights of the Child, it was ratified a minimum age for entering work as the International Labour Organization also specifies. Inspite of this, it is estimated that approximately 250 million children are working, the smallest of them having even less than 5 years. If the greatest number of them are in the southern poor countries, there are many children exploited in the Northern countries.

Within the European Union, the number of these children surpasses 2 millions. In the areas characterized by an ultra liberal reorganization, like UK, but even within the countries thought of as advanced from a social perspective (Denmark, the Low Countries), the phenomenon of child labour has remerged [8].

Regarding the positive reactions concerning these unbalances of the employment systems, they aim at enforcing more human working conditions on the whole planet. These efforts should be taking place more actively, for a long term, by all the trade-unions. If we take into consideration the textile industry, starting with a couple of year ago, Levi Strauss, Reebok and other companies represent the targets of the vehement criticism regarding their labour conditions and also those of their subcontractors. There have been noticed cases of physical violence, compulsory overtime, various dismissals of the employees that have tried to denounce certain situations. The gathering of the testimonies, TV reports or the media articles, generated apprehensions among companies that are always concerned with their own image. Some companies have considered that the elaboration of a code of conduct represents an efficacious method for protecting themselves against the negative effects of the negative mediatic campaigns that they have been submitted. Of all the codes of conduct made public, that of Levi Strauss company is considered to be the one of the best. This one contains only minimal issues. The employees must benefit of at least one day off work per week. The working week is 6 hours/day, and 14 is the minimum age in order to work here. The code ignores sexual harassment, a frequent problem in these companies, that hold in majority feminine workforce. Levi Strauss has approximately 700 subcontracted companies in 50 countries. The company was very appreciated by the public opinion when it announced that it was going to withdraw from Birmany on the ground that in this country the human rights weren't respected [9]. Moreover, the company ceased its collaboration with 35 contractors, on the ground of not respecting the code of conduct [10]; additionally announcing a gradual withdrawal from China.

Nevertheless, the simple elaboration and presentation of a code of conduct may represent an adequate answer to the problems of human resources management. Thus, in the North American countries, there has emerged the idea of an independent inspection, being proposed by several organizations, that should form a local comity, independent and trustworthy, that should be composed of representatives of the organizations that defend the people's rights or religious organizations.

This comity would afterwards deliver the information to companies like Nike or Levis that should pressure their subcontractors, in order to solve the situation. Nonetheless, the representatives of the two companies declared that an independent inspection would represent an encroachment onto the business of the companies.

9. International Work Norms

According to the southern countries, imposing restrictive social norms aims at preventing the penetration of the industrialized markets, that are trying to protect their producers [11]. Within the 85th sessions of the International Labour Conference, held in Geneva, the Director of the International Labour Office proposed to the 174 countries to revitalize the international labour standards, by adopting 3 types of reforms: 1. to ensure universal respect for fundamental human rights in the work place (union trade freedom and collective negotiations); indiscriminating work and the minim age for work; 2. establishing a surveillance mechanism regarding world wide social progress, relying on periodical reports; 3. Adopting a global social status, granted to the countries that respect the rules and that accept to subject their activity to an international inspection [12]. These norms are difficult to adopt. Institutionalizing a regulated minimum wage raises problems, because this emphasize the social inequalities. Moreover, the implementation of these norms is very difficult in the southern countries due to the fact that imposing the age of 15 as the minimum wage for work has various consequences [12].

10. Conclusions

In this paper I have started from the observation that the laws of the financial markets have imposed themselves brutally during the '90 and from back then, the enterprises commenced upon a path towards productivity and expansion, having as victims their own employees. In the name of competitivity, the enterprises are looking for a greater flexibility, a greater autonomy and freedom in administrating their own staff. And in this race towards an enormous profit in a time as short as possible, directly or indirectly the enterprises are always in search of workforce sources as cheap as possible. There emerge a few positive reactions, among which we mention the code of conduct, international labour norms or social clauses, but the activity of the trade unions is limited and powerless in front of the ultra liberal globalization. Warren Bennis used to say that in the future, the enterprise would have only two employees: a man and a dog; the man will feed the dog while the dog will prevent the man from laying his hands on the equipment.

Received November 17, 2008
Institute of European Studies "Ştefan Lupaşcu" Iaşi

REFERENCES

1. Buendia R., Estrada R.,, **Psicología del mexicano en el trabajo**, Serie Capacitación efectiva, México, MacGraw-Hill, 1999, **Doing business in Mexico, the human ressources challenge**, Business Quaterly, 2000, p.79
2. Pechter, K., **Career management: the Foreigners are coming**, International Business, Vol. 6, 9 september 2005, p. 120
3. * * *, **Plusieurs entreprises japonaises prestigieuses contraintes de licencier**, Nihon Keizai Shimbun , Tokyo, 4 september 2005, p.95
4. Lemaître F., **Gemplus expérimente une vision dynamique du rôle et de la classification de ses cadres**, Le Monde, 9 april 2005
5. Hiroatsu N.,, **Une nouvelle politique salariale pour les cadres japonais,** Liaisons sociales - le mensuel, mars 2006
6. Grozelier Anne-Marie, **Pour en finir avec la fin du travail**, Les Éditions de l'atelier, Paris, 1998, p. 156
7. Gorgeu Armelle, Mathieu R., **Filière automobile: intérim et flexibilité**, Centre d'études de l'emploi, Paris, 26 martie 2005, citat de Isabelle Mandraud în Libération din 14 aprilie 1998
8. Ramonet I., **Enfances fracassées**, Le Monde Diplomatique, january 2005, p.11
9. * * *, New-York Times Magazine, 2005, p. 18
10. Zuckoff M., **Taking a profit and inflicting a cost**, Boston Globe, 2004, p. 10
11. * * *, **Dumping «social » contre « protectionnisme»**, Le Monde, 1 november 1997.
12. * * *, **Le Bureau International du Travail cherche à s'adapter à la mondialisation de l'économie**, Le Monde, 7 june 1997

PRACTICI COMPARATE DE GESTIUNE A RESURSELOR UMANE PE PLAN MONDIAL UTILIZATE ÎN ŞTIINŢA MATERIALELOR

Rezumat: Articolul tratează contextul problematicii gestiunii resurselor umane, în cadrul noilor strategii ale firmelor multinaţionale din domeniul ştiinţei materialelor, care sunt în căutarea unei mai bune competitivităţi şi flexibilităţi. Se va urmări ilustrarea cercetărilor privind flexibilitatea; precum şi noile tendinţe în gestiunea resurselor umane în lume, externalizarea anumitor activităţi şi deci şi a personalului care le realizează.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

THE GLOBALIZATION OF THE HUMAN RESOURCES MANAGEMENT WITHIN THE METALLURGICAL INDUSTRY

BY

CRISTINA MARIA STOICA

Abstract: The globalization process, mainly orchestrated by the fast development of the multinational corporations, materializes by means of a homogenization trend regarding the functioning of the enterprises. The liberalization of the exchanges and the development of the foreign direct investments led to economic globalization.

Keywords: globalization process, foreign direct investments.

The globalization cannot be reduced to only this single quantitative dimension. The development of the foreign direct investments was accompanied by noteworthy transformations within the strategic and organizational plan. Throughout the 80’s and especially during the 90’s it was noted a transition from the multidomestic strategies, based upon the juxtaposition of the products - independent national markets pairs, to global strategies, oriented toward search.

Thus it result outsourcing and relocation movements regarding the functions less value-producing of the companies. Besides, after the 90’s, a new actor showed up- the institutional investors, that generated an incremement of the financial market importance in relation to the multinational corporations, favouring the short term productivity argument..

Regarding the organization, the emergence of the transnational company concept shows that in a certain number of situations, the mother companies are looking to cooperate with their foreign branches and not only to control them. The foreign branches can play different parts, using their abilities and their internal resources. The companies work within a network, thus being required varied verification mechanisms. Among them, the human resources and and their management become a key variable.

The globalization process marks a qualitative break-off regarding the companies’ manner of working. In the 80’s, the success of the Japanese companies led to the transfer of some of their manner of organization, regarding the human resources management towards Europe and North America. After the 90’s there was noted a diffusion of the Anglo-Saxon patterns.

If the globalization favoured, in some cases, a convergence of the practices concerning the human resources management, it is noted that despite the increasing interconnection of the increasing interconnection of the economies, the countries and the companies keep differentiating themselves. Within this process, the multinational companies play a major role.

The classification realized by Perllmutter, that highlights the relations between the mother company and its branches, represents an useful background:

- the ethnocentric relations: the organizational culture of the mother company is regarded as being better than that of the branches. On the strength of this principle, all the strategic decisions are taken at the headquarters, the branches being coordinated by expat managers and the management of the staff is centralized;

- the policentric relations: each foreign branch has its own strategy, the number of expat staff is low and there is no unitary staff politics;

- the regiocentric relations: within this type of company, the world is divided into regions, more or less homogeneous, from a cultural point of view. The strategic decisions are adopted at worldwide level and the other decisions are taken at the regional or national level. The staff mobility is of great importance within a region and the staff politics is set out at regional level; the geocentric relations: ensure an equality of chances for all the nations that make part from the group. The strategic decisions are taken at the headquarters, considered to be mondial. The staff politics is global and it does not represent only the preferences of a single nationality.

In the dint of this classification, the globalization of the human resources management materializes itself as a multiplication of geocentric type multinational companies, with a development of the international staff mobility and of the suitable management tools. These efforts aim at the most valuable potentials management that are meant to become future managers. It was noted an evolution regarding the profiles specific to international careers, as well as the utilisation of some unitary valuation tools, that allow the assessment of the staff performance, following the same criteria, regardless of the company's location.

The globalization of the strategies had as an effect the convergence of certain fields of human resources management, but following rather an ethnocentric logic. The American multinational companies have proven their capacity of creating international management systems and spreading these principles and tools.

The studies regarding this matter reach the conclusion that a convergence of these practices and tools toward an Anglo Saxon pattern that tends to become dominant throughout Europe.

The researchers even tend to speak about an aglo-saxonizing process of the European companies. This less defines the spread of an Anglo Saxon pattern, due to the supervision of the mother companies over their subsidiaries than adopting the methods characteristic to Anglo- Saxon multinational companies. This process mainly aims at the careers management and assessment: control and assessment, orientated toward short term performance, methods for career management and more detailed individualized payment.

Regarding the multinational careers management, global managers are wanted, capable of running the globalization process. For these individuals, the career management pattern valorises more the generalist profiles than the expert and specialist profiles. These employees possess high level abilities, easily transferable from a company to another.

The recruitment of these personnel categories is globalized. The globalization materializes itself also in the criteria and assessment tools. These are the result of the evolution toward multinational networks, of the transversal structure development and of the strategies' financial orientation. The Anglo-Saxon influence is shown by a distinct attention paid to the shareholder value and by implementing of certain connections between the manager's payment and the results of the companies.

The individualization of payments, as a field of human resources management, exemplifies this movement of the globalization process. The individualization consists in differentiating the payment, connecting a more or less important part of the wage to the productive contributions of the employee within the company.

The individualization takes the form of shareholding employee. Moreover, the attribute of the Anglo Saxon firms, this technic is spreading because it presents the advantage of income incrementent, in spite of the salary strictness. Although the remuneration politics remain established at national level, the shareholding employee represents a means for the multinational companies of disconnecting the payment politics from the national constraints. But, the individualization is conditioned by company adopting the formalized proceedings of individual performances assessment.

Despite the spreading of the Anglo Saxon patter, we cannot speak yet about a globalization of the human resources management, this because, the recruitment and mobility locations are in large majority national; some managements field are strictly subjected to national regulations.

Although in the beginning of the 90's the number of the managers considering that the international mobility was going to develop, in order to go along with the companies's strategies, the subsequent observations led to the conclusion that this mobility had not reached the predicted success and besides it acquired unexpected a priori shapes.

The mobility of the employees is part of the traditional mechanisms of coordinating within the organizations. It contributes to the development and the enrichment of the experience and it allows the assurance of a cultural control of the local employees and of the experience transfers. After the 90's, other forms of coordination have been significantly developing, as compared to expatriation, not all the time efficacious from an individual organizational and financial point of view.

In complementarity with the application of the transversal structures of project type the following forms if cvasi mobility have developed: visits, periods from 15 to 6 months that do not require the family shuffle. The IT and Communication Technology development, the possibility of creating global information systems, accesible wherever, required less the presence of the person's physical presence. We witness at the increasingly development of the virtual teams.

Regarding the recruitment, going global aims at the employees that offer specific abilities. The international mobility and the recuitment going global are connected to the human resources division, being strictly correlated to the level if individual qualification.

There emerge significant treatment differences among the non- manager employees (workers, technicians) and the managers that posses superior qualifications. For the first category the mobility and the recruitment location are the national ones. The surveys taken regarding the surveillance - development function of the globalization, specific to the over qualified employees, showed that at the end of the 90's the scientific explores recruited from abroad represented less than 3% in France.

The recruitment channels are often structured at national level. The globalization of the higher education that is going to become more and more prominent, will determine the evolution of this practice. Other tools of the human resources management politics still preserve the national basis, in connection to the juridical, institutional and cultural specificities. The payment systems are connected to the elements defined at national level (regulations, joint conventions) that represents for the company a restrictive action frame. The regulations concerning the minimum wages are rather different within Europe.

The enterprises are also constraint by the medium wage of the national work market. Even within the multinational companies, the wages are also settled in comparison with the local standards. Within the framework of the European Union, the differences regarding the annual medium wage, expressed by the buying power standard, that are still noteworthy and indicate a 1 to 10 ratio, between Latvia and UK (source: Eurostat) . these differences raise the problem of the impartiality with which the translational teams are treated, that tend to become more and more numerous.

The implementation of the variable component of the salary has been realized in different ways, depending on each country. There is no politics regarding the human resources management applicable in all the circumstances, due to the fact that it varies in conformity with the influence od the internal and external factors. Factors as the size, the company's lifetime, the strategy or the activity area keeps influencing the qualifications level and the nature of the accumulated abilities, the organization of the work, means of managing these abilities.

To these traditional factors, we must add the nationality of the multinational companies that determine their behaviour in what concerns the the organization, the coordination of the activities and the human resources management. Thus, the American multinational are rather centralized and favour the formal mechanisms of coordination, while the Japanese companied are well-known for the development of the informal mechanisms, thus promoting a joint company culture.

Since many years there is a culturalist trend that is looking to show in what proportions the countries keep differentiating from the mental scheme point of view or the value systems. Starting from a study carried out on an American multinational company, Geert Hoftede, defined a cultural distance among the countries, according to four criteria:

- *the hierarchical distance*, that measures the degree of acceptance of the subordinates regarding the unequal power allocation;
- *the degree of individualism versus the collectivism*, that measures the degree of integration of the individuals within the collectivity
- *the degree of masculinity versus feminity*, defined by taking into consideration the degree of adhesion to the masculine values(like success or possession), rather than the feminine values (solidarity) and the degree of interchanges of social roles, depending on sexes
- the control of the uncertainty, that determines the members of an organizations with a certain culture to feel menaced by uncertain or unknown situations. This cultural distance has repercussions against the human resources management. The practices of human resources management keep varying depending on the countries, due to the fact that these are subscribed to cultural contexts, which fundaments are placed in the long history specific for these countries.

Another explanation of the national specificity persistence is that of the institutionalist trend, that places in the centre of the analysis the roles of the institutional managers. What sets apart the countries and the national practices in what concerns the human resources management, is not the culture, but the result of the action in a given social location, of the actors or the economic, politic and social structures. Richard Whitley analyses the countries as being systems that include three major components, inter-conditioning themselves: the enterprises as economic actors, the market's organization and the coordination and control systems from within the societies. The organization of each socio-economic system is determined by the influence of the key institutions, that can be of two types: basic institutions, with which there are established trustworthy, cooperation or authoritative relations, that are based upon interpersonal relations and allow the co-operation between the individuals and the organizations; institutions that aim at the state part, the type of financial market, the organization of the educational system and professional relationships. In Asia for example, the structure of the hierarchical relations within the enterprises is carried out by revaluating the familial loyalty, as a central institution. The Asian countries set themselves apart through their recent history, in what concerns the role more or less central of the state or of the work relations nature.

In the 70's, starting from the different salary scale used in France and Germany, the researchers proved that the differences come from the structural interdependence, characteristic for each country, between the educational system , the production system and the professional relations system. Within the enterprises, the human resources management, particularly the competency management, the promotion and payment system are closely connected to the manner in which they are produced, hierarchies and valorised the formation system. Thus, we can better understand why, despite the globalization process of the strategies, the number of practices regarding the human resources management is different from one country to another. These practices are part of the national institutions ensemble that make up the system. This does not mean that these ensembles are unchanging, but one must be conscious of the fact that these cannot be instantaneous, and their perenniality depends on the compatibility to other components of the system.

In conclusion, we must specify that in the last years there has been noted a spreading of the principles, tools and practices of human resources management, the main source being the Anglo Saxon countries. For the great multinational groups, the globalization of the strategies increases the reserve regarding the human resources management. It is also true that the enterprises, no matter the domain they belong to, keep differentiating themselves from the human resources management point of view. There is a certain persistent tensions between a structural variability of the human resources management and the presumptive globalization process

Received November 17, 2008
Institute of European Studies "Ştefan Lupaşcu" Iaşi

REFERENCES

1. Michael, P., **Competition in Global Industries**, Harvard Business School Press, Boston, 1986
2. Bartlet C., Goshal, S., **Le management sans frontiere**, Editiond, Organisation, Paris, 1991
3. Geert H., **Culture's Consequences: International Differences in Work-Related Values**, Beverly Hills, C.A., Sage, 1980

4. Frner, A., Quintaniella, J., **Multinationals, National Business Systems and HRU: the Enduring Influence of National Identity or a Process of Anglo-Saxonization**, The International Journal of Human Resource Management, nr. 9:4, 1998
5. Huault, I. **Le management international**, Edition La Decouverte, Paris, 1998
6. Beret, P., Mendez, A., Paraponaris, **Personnel and Human Resource Management in Multinational Companies: Between Homogenisation and Differentiation**, International Journal of Human Resource Management, nr. 14:3, 2003
7. Richard W., **Societies, Firms and Markets: the Social Structurring of Business**, Sage, London, 1992
8. Maurice M., Selliert, **Politiques d'education et organisation industrielle en France et en Allemagne. Essai d'analyse societale**, Puf, Collection Sociologie, Paris, 1982
9. Pasquero J., **L'entreprise face aux pression socio-politiques de son environnement**, I.A.E de Grenoble, 1990
10. Armstrong M., **A Handbook of Personnel Management Practice**, Kogan Page, London, 1991
11. Ivancevich, J.M.; Glueck, W.F., **Foundations of Personnel**. Business Publications, 1993

INTERNAȚIONALIZAREA GESTIUNII RESURSELOR UMANE ÎN INDUSTRIA METALURGICĂ

Rezumat: Procesul de mondializare, orchestrat în mare parte de dezvoltarea rapidă a firmelor multinaționale în domeniul metalurgic, se concretizează printr-o tendință de omogenizare a funcționării întreprinderilor. Liberalizarea schimburilor şi dezvoltării investițiilor directe în străinătate, au condus la globalizarea economiei şi implicit a industriei metalurgice. Globalizarea nu poate fi redusă totuşi doar la această singură dimensiune cantitativă. Dezvoltarea investițiilor directe în străinătate, a fost însoțită de schimbări semnificative în plan strategic şi organizațional. Pe parcursul anilor ʼ80 şi în special a anilor ʼ90, se înregistrează o trecere de la strategiile multidomestice, bazată pe o juxtapunere a cuplurilor produse-piețe naționale independente, la strategiile globale, orientate spre căutare.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secția
ŞTIINȚA ŞI INGINERIA MATERIALELOR

THE QUANTITATIVE DIFFRACTOMETRIC DETERMINATION OF THE QUARTZ IN SANDS AND FORMING MIXTURES

BY

NASTACA TIMOFTE and BOGDAN NICOLAU

Abstract: The great variety of modern metallurgical technologies imposes higher and higher exigencies for the quality of forming mixtures based on quartz sand.

The paper approaches an important subject in metallurgy and namely that of applying a very fast and exact method for the quantitative difractometric determination of quartz in sands and forming mixtures.

Keywords: quartz, diffractometric, forming mixtures.

1. Introduction

The quality of sands and forming mixtures depends on the quantity of contained quartz. The composition of the cast metallic material: steel, cast iron, nonferrous alloys or materials of high purity is related to the quality of forming mixtures based on quartz sand. The quality of quartz sand necessary in the forming mixtures depends on the dimensional range of the cast pieces.

For determining the quartz content of the quartz sand and forming mixtures we established a rapid method of quantitative diffractometric analysis method.

2. The method principle

The difractometric method for the qualitative determination of phases of rock minerals is based on the principle according to which the integral intensity of a maximum of diffraction, characteristic of a mineral is proportional with the volume fraction occupied by that mineral. The minerals present in a sample subject to the diffractometric analysis absorb differently the X rays, which imposes to take into consideration the absorbent properties.

The mixture of n minerals from a rock sample is considered (Klug and Alexander, 1974) as a system with two components: the component q whose concentration we search and the rest of minerals, named together M matrix.

The integral intensity of a maximum of hkl diffraction of the q component is given by the relation:

$$I_{hkl}^{(q)} = \frac{K_{hkl}^{(q)} xq}{\rho_d (x_q(\mu_q^* - \mu_M^* + \mu_M^*))} = \frac{K_{hkl}^{(q)} xq}{\rho_q \overline{\mu^*}} \tag{1}$$

with:

$$\mu_m^* = \sum_{j \neq q}^{q=1} / 1 - x_q \text{ , } \mu^* = \sum \mu^* x_j = x_j \mu_j^* + (1 - x_j) \mu_M^* \tag{2}$$

where μ_M*= the mass coefficient of abortion of the q mineral, searched; μ_M*= the mass coefficient of M matrix absorption; μ*=the mass coefficient of mixture absorption; x_q= the mineral concentration; ρ_q= the density of q mineral; $K_{hkl}^{(q)}$= constant characteristic to the maximum of diffraction hkl, which depends on the q component determined also by the experimental geometry used.

The rock sample is a mixture of n minerals and $\mu_q^* \neq \mu_M$. If this sample is added, in known quantity, a different mineral, which plays the role of internal standard, then we must no longer calculate the absorption coefficient of the mixture or the other factors on which the intensity of X rays diffracted depends on.

The mineral used as **internal standard** must accomplish the following conditions:

- to produce net diffraction maxims;
- the diffraction maximums of the standard must be similar to the maxims characteristic with the determined miners;
- the diffraction maximums of the standard must not be superposed with the diffraction lines of the sample mineral.

For determining the x_q concentration of the sand quartz, as an internal standard we use the fluorine, which accomplishes the mentioned conditions. We used the maximum of diffraction of the quartz which corresponds to the reticular plans ($10\bar{1}0$) with d = 3.3dA.

From fluorine we used the maximum of diffraction which corresponds to the reticular planes (111) with d = 3.16A.

3. Tracing the calibration line

For tracing the calibration line we chose three clean minerals: octahedral crystals of green fluorine, transparent crystals of hydrothermal quartz and rhombohedra of hydrothermal calcites. After their increase for a chemical analysis, we registered their diffractograms and we ascertained that they are structurally clean, not containing any other mineral in the mixture. Of the three monomineral powders we prepared 8 mixtures each consisting of a gram of fluorine and known quantities of quartz and calcites (tab no 1).

Then we executed the diffractograms of the 8 known mixtures (fig no 1) and we determined with the DRON-3 apparatus the integral intensity of the diffraction maxim of the quartz and integral intensity of the maximum of diffraction (111) of fluorine, using for this the method of automatic integration of surfaces.

Table 1. Quartz + calcites + fluorine achieved for tracing the calibration line

No. of mixtures	Grams		
	Quartz	Calcite	Flouorine
1	2,0	0,0	1,0
2	1,4	0,6	1,0
3	1,2	0,8	1,0
4	1,0	1,0	1,0
5	0,8	1,2	1,0
6	0,6	1,4	1,0
7	0,4	1,6	1,0
8	0,2	1,8	1,0

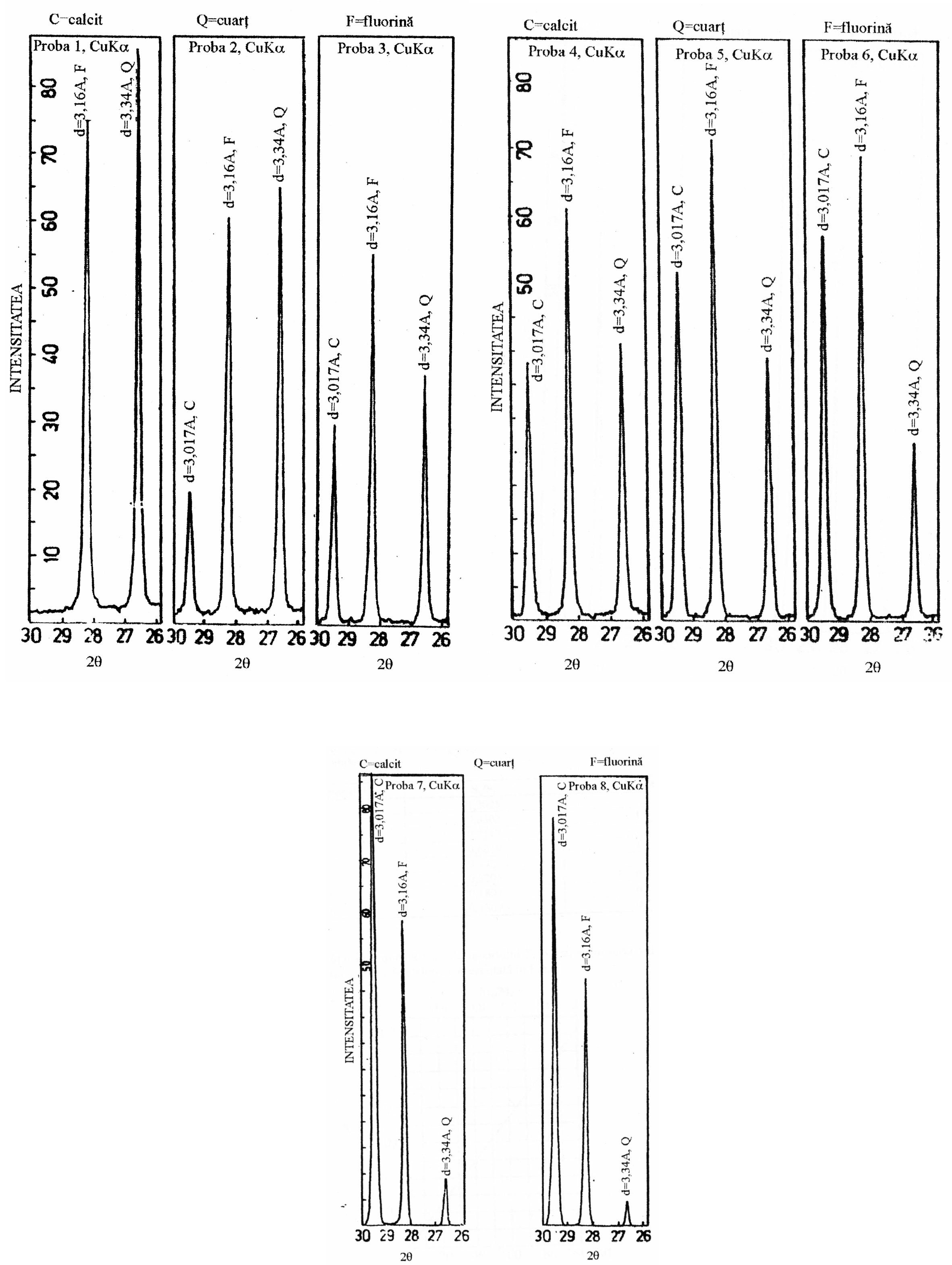


Figure 1. The diffractograms of the mixtures of quartz + calcite + fluorine (samples 1;2;3;4;5;6;7;8)

In table 2, we present the values of this relation presented as $S_{q/f}$ together with the relation grams quartz/grams fluorine, presented as M_q/M_f.

Table 2. The relation q/S_d and the relation M_q/M_f for the mixtures achieved in view of tracing the calibrator curve

Mixtures no.	S_{q}/S_r	M_q/M_r
1	1,2025	2
2	0,8302	1,4
3	0,7117	1,2
4	0,6019	1,0
5	0,4924	0,8
6	0,3705	0,6
7	0,1807	0,4
8	0,1809	0,2

Having in the ordinate line the values of the relation Sq/Sr and in the abscise the values of the relation m_q/m_f, we have traced the calibrating line presented in figure 2.

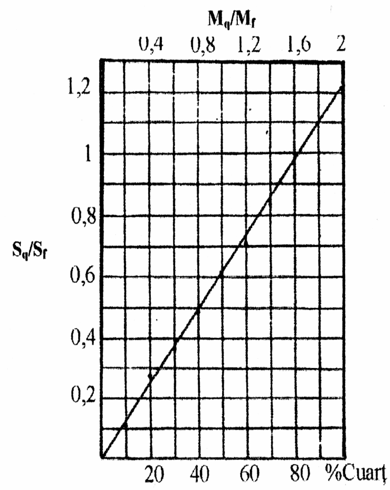


Figure 2. The calibration line for determining the content in quartz from the sands and forming mixtures.

4. The results of experimental determination

We have analyzed the quartz content per 10 systematically collected samples from a vertical profile of 10 m sand of Bârnova, opened in the perimeter of Pocreaca village (Iaşi county). Each sand sample was collected from a stratigraphic thickness of 1 m sand. The homogenized sample was reduced through quarter sample and then 5 g of sand were mortared in agate mortar. Two grams of powder obtained like this were mixed with 1 g powder of fluorine and then the mixture was well homogenized, constituting the difractometric sample. The 10 mixtures prepared like this were exposed to the X rays and successively registered for each, the diffractograms on the integral 20 = 11°, until 20= 14°. The surfaces of picks $(10\overline{1}\overline{1})_q$ and respectively $(111)_f$ were automatically registered in the DRON-3 apparatus.

From the values obtained we calculated the relation S_q/S_f that we projected in the diagram from fig. 5, on which we read the quartz content of the analyzed sand. The analytical results are mentioned in table no 3.

Table 3. The quartz content of the Bârnova sand, determined diffractometrically.

Sample no.	Quartz percentages	
	Gross sand	Washed sand
1	89,28	91,72
2	87,06	88,10
3	87,56	88,59
4	86,91	89,64
5	86,32	88,91
6	88,61	93,42
7	89,00	94,71
8	87,53	91,28
9	89,50	92,49
10	88,21	90,16

5. Conclusions

The difractometric method of quantitative determination of the quartz content in sands is characterized through rapidity and precision. With the DRON-3 we can determine 5 samples per hour, with a precision of 1-3%. The method replaces successfully the microscopic methods and happily completes the chemical analyses. It allows the execution of the quality control necessary for the sand and any forming mixture used in industry.

Received November 17, 2008

Technical University "Gh. Asachi" Iaşi

REFERENCES

1. Alilincăi, Gh.,Hopulele, I., Mălunreanu, I., Bâgu, Gh., **Studii asupra unor nisipuri din Moldova cu privire la posibilitatea folosirii lor în amestecuri de formare**,Buletinul I.P.Iaşi.1970.
2. Klug, H.P. and Alexander, L.E., **X-ray diffraction procedures**, John Wiley and sons Inc. New York.
3. Sofroni, L. et al., **Bazele teoretice ale turnării**, E.D.P. Bucureşti.1980

DETERMINAREA DIFRACTOMETRICĂ CANTITATIVĂ A CUARȚULUI DIN NISIPURI ŞI AMESTECURI DE FORMARE

Rezumat: Marea varietate a tehnologiilor metalurgice modern impune exigente tot mai mari la calitatea amestecurilor de formare pe baza de nisip cuarțos. Lucrarea abordează un subiect important în metalurgie şi anume cel al aplicării unei metode foarte rapide şi exacte a determinării defractometrice cantitative a cuarțului din nisipuri şi amestecuri de formare.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secţia
ŞTIINŢA ŞI INGINERIA MATERIALELOR

EXPERIMENTAL MODEL DESIGNED FOR MATHEMATICAL SIMULATION OF STEEL SAMPLES CASTING PROCESSES FOR APPLICATION AT SOME CASTING TECHNOLOGIES DETERMINATIONS WITH REDUCE MATERIAL AND ENERGY CONSUME

BY

DOREL BUTNACIUC, DUMITRU MIHAI, MIHAI ŞTEFAN, NICANOR CIMPOEŞU

Abstract: This study presents a program realization to establish a casting technology with reduced materials consumes and energy for a steel reference, which suppose to prevent the negative effect of contraction. With respect for physical phenomena was presented few hypotheses of mathematical model and base equations system connected with initial and limit conditions.

Keywords: simulation, numerical model, model design.

1. Introduction

Shrink holes form process analyze, the existent commercial programs on world scale contain the pouring simulation, thermal conduction with phase transformation and solidification latent heat release embedment and less the phenomena connected to contraction and shrink holes formation.

Using numerical methods to analyze the solidification process give the possibility of his current way knowledge; the calculated dates after numerical calculations will permit the temperature field knowledge from alloy, the solidification front evolution, quantity of ladle skull alloy and solidification rate, shrink holes volume and her time evolution. Numerical models for thermal analyze offer the possibility of two types of problems resolving which are directly problems, connected to solidification process determination and those inverses connected to determination of some thermal transfer coefficients.

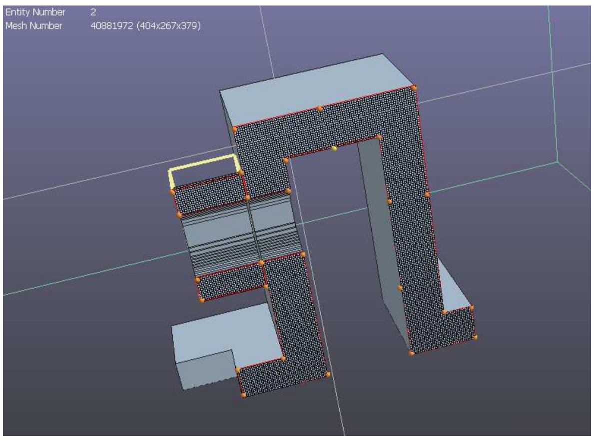


Figure 1. Steel bench model representation

2. Physical-numerical model

At shrink holes formation simulation is suppose that decrease of mass alloy accupied is compensate by a liquid alloy flux, what means that area type paste doesn't represent a significant obstacle at liquid alloy pouring. Decreasing of occupied volume of solidificated alloy create a pressure gradient which engage the alloy from near regions. If the area type paste permit the pouring of liquid alloy then shrink hole are formatted by decreasing of free surface of liquid alloy volume in contact with this type of area contrarily in paste area appear microscopic discontinues.

With help by numerical model were realized appreciations about next problems:

- Contraction influence from solidification range on shrink hole formation (the novelty element for energetic balance is made by the release appreciation of latent solidification heat);
- Cast iron chemical composition influence express through equivalent carbon intermedium of formation process of shrink holes.

The gauge sample was done in more technological variants as:

- form made only by one forming material (unique forming mixture);
- form made by more then one types of material, and using them to simulate diverse variants of front solidification leading.

Adjustment of model function supposes a careful study of numerical, physical and technological parameters, some examples are presented in figure 2.

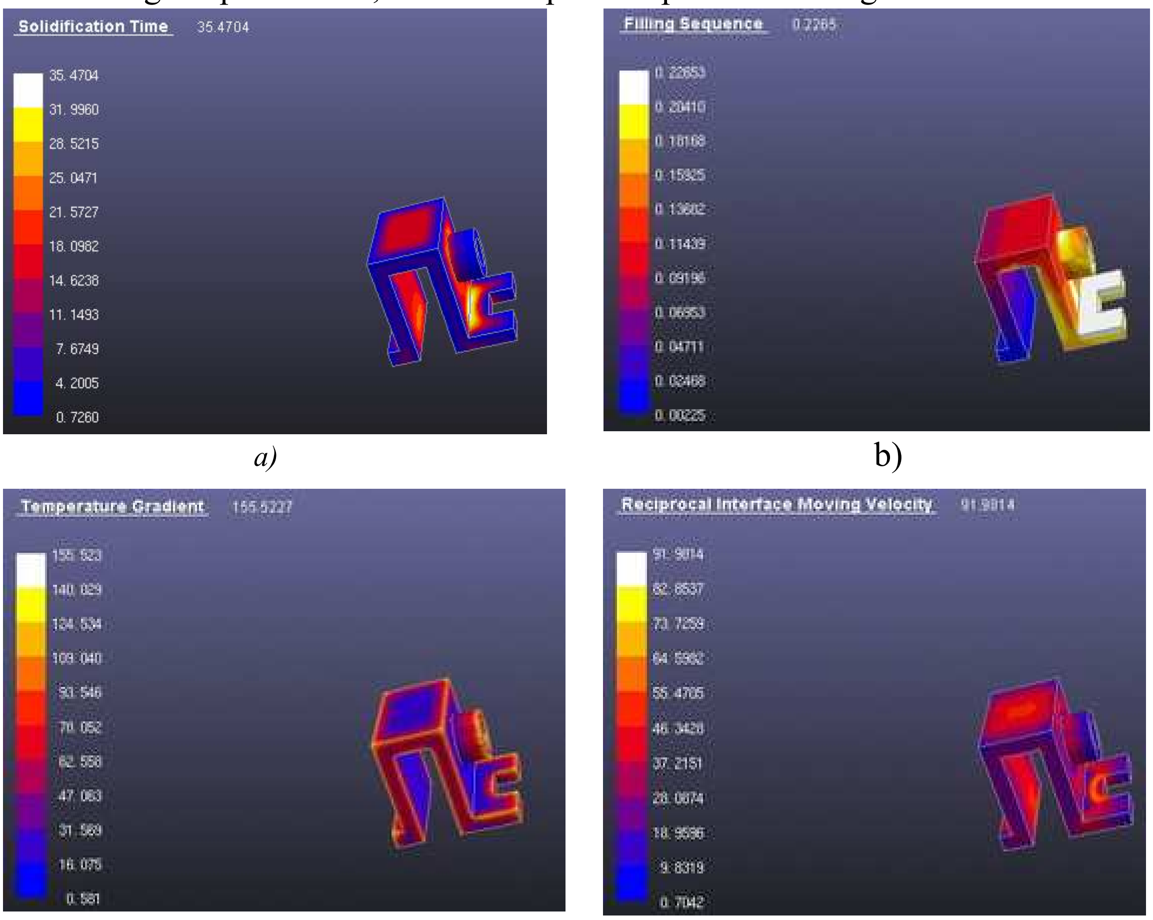


Figure 2. Simulation depending on different parameters a) solidification time b) filling sequence c) temperature gradient d) reciprocal interface velocity

3 Hypothesis of model and base equations system

Numerical modelation of pouring must take account by physical phenomena which interfere at the beginning of shape filling up until total solidification of cast piece. Filling up of shape with melted alloy is treated as viscous pouring with free surfaces. During cooling of alloy a distinguish stage is made by solidification process accompany by solidification latent heat release. This stage is also accompanied by shrink holes and micro-porous formation producing different casting defects

In numerical treatment of solidification process a difficult problem consist in existence of two mobile borders. One is the free surface of liquid alloy during the fill up process of the shape, and the other one is the solidification front which separates the region of alloy complete in solid state by areas with partial solid or liquid alloy. For free surfaces treatment appears three types of problems: discrete representation, their time evolution and the way are imposing the limit conditions. A simple and efficient method for this problem resolving is a method type VOF (Volume of Fluid) used by authors and adapted to the purpose.

In our approximation the superficial phenomena are negligee. As well we will negligee and the chemical composition changes which can take place in both separate domains by solidification front. In what came next will suppose that material constants don't depend by temperature. The model equations are based on fundamentals physic principles expressed by conservation relationships of movement quantity of mass and heat. In cylindrical coordinate's ax- symmetrical rOz, the functions not depend by φ differential equations which express the movement quantity conservation in coordinate's axes direction Or and Oz, have form:

$$\frac{\partial(\rho u)}{\partial t}+\frac{1}{r}\cdot\frac{\partial(r\rho uu)}{\partial r}+\frac{\partial(\rho wu)}{\partial z}=\frac{\partial p}{\partial r}+\frac{\partial}{\partial r}\left(\mu\frac{\partial u}{\partial r}\right)+\frac{\partial}{\partial z}\left(\mu\frac{\partial u}{\partial z}\right)+\frac{\mu}{r}\cdot\frac{\partial u}{\partial r}-\mu\frac{u}{r^2} \qquad (1)$$

$$\frac{\partial(\rho w)}{\partial t}+\frac{1}{r}\cdot\frac{\partial(r\rho uw)}{\partial r}+\frac{\partial(\rho ww)}{\partial z}=\frac{\partial p}{\partial z}-\rho g+\frac{\partial}{\partial r}\left(\mu\frac{\partial w}{\partial r}\right)+\frac{\partial}{\partial z}\left(\mu\frac{\partial w}{\partial z}\right)+\frac{u}{r}\cdot\frac{\partial w}{\partial r} \qquad (2)$$

And the mass conservation equation can be writing:

$$\frac{\partial\rho}{\partial t}+\frac{1}{r}\cdot\frac{\partial(r\rho u)}{\partial r}+\frac{\partial(\rho w)}{\partial z}=0 \qquad (3)$$

Notations are known by specialty literature: *u and w are vector projections of rate on coordinate's axes* Or and Oz, *t is time*, ρ density, *p* pressure and μ kinematical viscosity. With *g is noted the gravitational acceleration constant.*

The heat conservation equation can be put as:

$$\left(c-L\frac{\partial f_s}{\partial T}\right)\frac{d}{dt}(\rho T)=\frac{1}{r}\frac{\partial}{\partial r}\left(r\lambda\frac{\partial T}{\partial r}\right)+\frac{\partial}{\partial z}\left(\lambda\frac{\partial T}{\partial z}\right) \qquad (4)$$

where is noted $\frac{d}{dt}=\frac{1}{r}\frac{\partial(ru)}{\partial r}+\frac{\partial(w)}{\partial z}$, T temperature, λ thermal conductivity coefficient, c specific heat at constant pressure and L the solidification of alloy latent heat. The dependent value $f_s=f_s(r,z,t)$ are named volume solidified fraction and is define as:

$$f_s(r,z,t) = \begin{cases} 0, & \mathrm{T} > \mathrm{T_l} \\ \dfrac{T_l - T(r,z,t)}{T_l - T_s}, & T_s \le T(r,z,t) \le T_l \\ 1, & \mathrm{T} < \mathrm{T_s} \end{cases} \tag{5}$$

Relation (5) represents one of the possible options to define the function form f_s . With T_l *is note the temperature liquidus* of alloy, and with *Ts* temperature solidus. It seems that when f_s *(r,z,t)* E (0,1) in point (r,z) is find a liquid solid mixture. The mechanical properties of this mixture are complexes but we adopt a simple and usual approximation: if f_s >= 0.3 then the mixture is considering a rigid solid, and if f_s < 0.3 then the liquid alloy can flow by microscopic structures of solidified alloy and the additional resistant force owing to solidification degree of mixture is simulated by viscosity alloy modification conforming to relationship (6):

$$\mu := \frac{\mu}{(1-\mathrm{f_s})^n} \tag{6}$$

where $n \in [5,30]$.

In this context relation (6) represent one of the simulation modalities of interaction between solid and liquid phases in mixture region. Also is suppose that solid alloy cannot participate at pouring and because of that in equations (1) - (3) the density must be equal with liquid alloy density ρ_l and not with mixture density. This hypothesis corresponds in especially to situation where the biphasic region morphology is likely that contain only dendrites as plates and columns. If the mixture region contains echi-axial granules free floating then density in equations (1) - (3) will have the mixture density value. Equation (1.6) can be explain only in alloy domain and the density that interpose in her is always equal with mixture density

$$\rho = (1-f_s)\rho_l + f_s\rho_s \tag{7}$$

And by analogy the specific heat and thermal conductivity coefficient is:

$$c = (1-f_s)c_l + f_s c_s \tag{8}$$

Expression $c - L\dfrac{\partial f_s}{\partial T}$ from relation (4) appears by specific equivalent heat method application, which is one of the ways through we can take account by solidified latent heat emanation.

To calculate the thermal exchange from inside of domain occupied by shape next equation is utilized:

$$\rho_m c_m \frac{\partial T}{\partial t} = \frac{1}{r}\frac{\partial}{\partial r}\left(r\lambda_m \frac{\partial T}{\partial r}\right) + \frac{\partial}{\partial z}\left(\lambda_m \frac{\partial T}{\partial z}\right) \tag{9}$$

where ρ_m , c_m si λ_m are form density, specific heat and conductivity.

$$\rho_r c_r \frac{\partial T}{\partial t} = \frac{1}{r}\frac{\partial}{\partial r}\left(r\lambda_r \frac{\partial T}{\partial r}\right) + \frac{\partial}{\partial z}\left(\lambda_r \frac{\partial T}{\partial z}\right) \tag{10}$$

where ρ_r, c_r si λ_r are cooler density, specific heat and conductivity.

4. Initial and limit conditions

If we note with D_m the space domain of form, with D_t dthe full domain with liquid alloy , with D_s the domain which contain solidified alloy, cu D_r domain occupied by cooler – if exist one- and with D_a the domain of partial solidified mixture area. Domains D_t , D_s, D_a are depended by time. In initial moment inside the form doesn't exist an alloy so D_t=Ø and implicitly D_s= Ø and D_a= Ø, and space by inside of form contain air in normal pressure and temperature conditions. Since specific density and heat of air are much smaller them specific density and heat of alloy and of form material, will negligee the mechanical and thermal phenomena which appear in air.

At initial moment t =0, we have next conditions:

$$\begin{cases} u(r,z,0)=0 \\ w(r,z,0)=0 \\ p(r,z,0)=0, \quad \forall(\mathrm{r,z})\in D \end{cases}$$

where with D is noted the occupied domains reunion by form, cooler and air from cavity.

$$\begin{cases} T(r,z,0)=T_{m0}, \quad \forall(\mathrm{r,z})\in D_m \\ T(r,z,0)=T_{r0}, \quad \forall(\mathrm{r,z})\in D_r \\ T(r,z,0)=T_0, \quad \forall(\mathrm{r,z})\in D_{aer} \end{cases} \tag{11}$$

Where T_{mo} is the initial temperature of form usually equal with ambient environment temperature T_o, but in case of preheating forms T_{mo}> T_o. T_{ro} is the initial temperature of the cooler.

The limit conditions for rate components at the border between liquid alloy and form wall or cooler wall even at the border between the liquid alloy and the solidified alloy are: $u(r,z,t)=0, \quad w(r,z,t)=0 \quad \forall t\geq 0$.

The free surface of liquid alloy, ∂D_l, is compound by two parts, one is the alimentation surface S_a.on which we have:

$$u(r,z,t)=u_0(t), \quad w(r,z,t)=w_0(t) \quad \forall t\leq t^* \tag{12}$$

- where t^* is the alimentation time and u_o *and* w_o are alimentation rate components and are given functions. For $t > t^*$ we have $u_o(t) = 0$ and $w_o(t)$ = 0. On portion ∂D_l - S_a the tangential tension must be zero, and the normal tension must equilibrate the external pressure p_o. These conditions can be mathematically express helping by gradient and rate and the free surface orientation in this way:

$$\begin{cases} 2n_r m_r \dfrac{1}{r}\dfrac{\partial(ru)}{\partial r}+(n_r m_z+n_z m_r)\left(\dfrac{\partial u}{\partial z}+\dfrac{1}{r}\dfrac{\partial(rw)}{\partial r}\right)+2n_z m_z\dfrac{\partial w}{\partial z}=0 \\ 2\nu\left[n_r n_r\dfrac{1}{r}\dfrac{\partial(ru)}{\partial r}+n_r n_z\left(\dfrac{\partial u}{\partial z}+\dfrac{1}{r}\dfrac{\partial(rw)}{\partial r}\right)+n_z n_z\dfrac{\partial w}{\partial z}\right]=p_0 \end{cases} \tag{13}$$

- where n_r , m_r and m_z are the unit vector and tangential unit vector properties at free surface, and v is the dynamic viscosity of liquid alloy. It's seems that to impose the limit conditions for *u* and *w* is necessary the determination of free surface orientation. For temperature field the limit conditions on separation surfaces between the liquid and solid alloy, liquid alloy and form wall or cooler wall, solidified alloy and form wall or cooler wall are expressed by equalization of heat fluxes:

$$\lambda_1 \frac{\partial T_1}{\partial n} = \lambda_2 \frac{\partial T_2}{\partial n} \quad (14)$$

5. Conclusions

Researches made in this study leading in the end to next conclusions:

- the verified results made show that the mathematical model and program structure for pc to simulate solidification and casting technologies projection with low consumes for conversion, materials and energy elaborated above are correct.
- comparing of obtained results by simulation of solidification of some cast pieces with help from calculus program (soft) to simulate some similar pieces demonstrate the the correct thinking of this soft.
- the experimental researches make a point of improvement possibilities of some experimental similar programs and extension of researches on structure uniformity and steel pieces properties on section.

Received November 30, 2008

**Technical University "Gh. Asachi" Iaşi*

REFERENCES

1. Ienciu, M., Moldovan, P., Panait, N., Buzatu, M., **Elaborarea si turnarea aliajelor neferoase speciale**, Editura Didactica si Pedagogica, Bucuresti, 1985.
2. Moldovan, P., Panait, N., Margineanu, St., **Bazele tratarii topiturilor metalice neferoase**, Editura Intact, Bucuresti, 1998.
3. Sofroni, L., Brabie, V., Bratu, C., **Bazele teoretice ale turnarii**, Editura Didactica si Pedagogica, Bucuresti, 1980.
4. Carcea, I., **Bazele elaborarii metalelor, aliajelor si superaliajelor neferoase**, Editura Cermi, Iasi, 1998.
5. Soporan V., Vamoş C., Pavel C., **Modelarea numerică a solidificării**, Editura Dacia , 2003
6. Mihai D., **Rezistenţa materialelor de la A la Z , volumul I**, Editura Vie, Iaşi, 2002.
7. Mihai D., **Rezistenţa materialelor de la A la Z, volumul II**, Editura Vie, Iaşi, 2002.
8. Istrate G., Toboc, P., **Controlul de calitate şi remanierea pieselor turnate**, Ed. Didact. şi Pedag., Bucuresti, 1981.
9. Anders E.W., Jarfors, Esa Ervasti – **Simulation and Modeling in Materials Processing**, Lund, Sweden 2001
10. * * *, **Ranconsoft**, simulation program Iasi 2008

PROIECTAREA MODELULUI EXPERIMENTAL DESTINAT MODELĂRII MATEMATICE A PROCESELOR CARE AU LOC LA TURNAREA PIESELOR DIN OŢEL, PENTRU APLICAREA LA STABILIREA UNOR TEHNOLOGII DE TURNARE CU CONSUMURI REDUSE DE MATERIALE ŞI ENERGIE

Rezumat: Acest studiu prezintă realizarea program pentru stabilirea unei tehnologii de turnare cu consumuri reduse de materiale şi energie a unui reper din oţel, care să prevină efectul negativ al contracţiei. Ţinând cont de fenomenele fizice au fost date câteva ipoteze ale modelului şi sistemul de ecuaţii de bază ţinând cont de condiţiile la limită.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIV (LVIII), Fasc. 3-4, 2008
Secția
ŞTIINȚA ŞI INGINERIA MATERIALELOR

METALLIC MATERIALS BASED ON ALUMINUM. A DILATATION STUDY USING DIFFERENTIAL EQUIPMENT

BY

NICANOR CIMPOEŞU, SERGIU STANCIU, ROXANA CARABEȚ, BOGDAN ISTRATE

Abstract: An alloy based on aluminium-silicon was investigated to establish his thermal stability using a differential equipment type dilatometer. Alloys based on aluminium, because of them special properties are used in different industrial areas like aeronautic field as slightly elements but in the same time with nice metallic material properties. The alloys were investigated with a spark spectrometer for chemical composition determination, the microstructures are obtained by optical microscopy and the behaviour at heating process was determinate with a differential dilatometer.

Keywords: differential dilatometer, aluminium alloy.

1. Introduction

Aluminium is most spread metal in earth shell, and between elements is third behind oxygen and silicon. Because of his big chemical activity aluminium is finding in nature only as compounds, with oxygen and silicon form 82,58% from earth shell. Physical properties and mechanical characteristics of different kinds of aluminium are influenced by impurities presence. Most often impurities from aluminium are iron and silicon elements which can be found until 0,5-0,6 % percent each. The iron is practical insoluble in aluminium forming the eutectoid Al-Al3Fe which contain only 7% Al3Fe (1,7%Fe). The eutectic from system Al-Si is formed at 11,7% and Si is made by solid solution and silicon. If in the same time are presented simultaneous iron and silicon are forming two new phases: (Fe3SiAl3) and phase ß (FeSiAl5), which doesn't exist in binary alloys. This compounds situated usually at crystals limits decrease a lot the alloy plasticity.

Aluminium is part of IIIA group in periodical elements system, have a single stable isotope 27Al and five radioactive isotopes (24Al,25Al,26Al,28Al) with half periods between 2,10 and 94 seconds. Aluminium is characterized by a very big plasticity, small mechanic resistance, high electrical and thermal conductibility and big corrosion resistance in air, water and organic acids.

The aluminium – silicon (Al-Si) alloys are used very much in melting houses because of them superior casting properties comparing with other aluminium based alloys. Alloys Al-Si are hypoeutectoid when the silicon is in concentration lower then 11.7% and hypereutectic when silicon is in bigger concentrations. In first case them structure is formed by solid solution alpha of silicon in aluminium and by solid solution beta of aluminium in silicon and eutectic, in second case.

The eutectic alloys are more fluid so they have the best casting properties, the cracking risk at warm doesn't exist in this materials case also no micro shrink holes appear what give them a better resistance for tightness, similar properties have the hypereutectic alloys.

Because of the approach to eutectic all aluminum-silicon alloys have a nice filling up form capacity so excellent casting properties. Corrosion resistance is fine in ordinary atmosphere and quite sufficient in sea water for alloys with small amounts of iron.

Mechanical workability is medium because the alloys are soft and hold by the knife, most usual utilization is in very thin walls an complicated pieces field where is expected tenacity and tightness in the same time.

The increasing of a body dimensions phenomena at heating is named thermal dilatation. As an exception to the rule a shape memory alloy manifest by a contraction during heating, rest of the metallic material increasing in dimension during this process. If is consider the increasing of only one dimension of the body we are talking about linear dilatation characterized by linear dilatation coefficient.

Is define the linear medium dilatation coefficient $\bar{\alpha}$, for dilatations corresponding to a finite temperature variation ΔT = $T_1 - T_2$ and linear dilatation coefficient α when temperature variation is infinitely small.

$$l_1 = l_0 |1 + \bar{\alpha}\,(T_1 - T_0)| \tag{1}$$

where: l_1 and l_0 are body lengths at temperature T_1 respectively T_0.

$$\bar{\alpha} = \frac{l_1 - l_0}{T_1 - T_0} * \frac{1}{l_0} = \frac{\Delta l}{\Delta T}\frac{1}{l_0} \tag{2}$$

and

$$\alpha = \frac{dl}{dT}\frac{1}{l} \tag{3}$$

The thermal dilatation coefficients are measure in $[C^{-1}]$.

2. Experimental equipments

For chemical analyze was use an fast and precise emission spectrometer type Foundry Master, found in Materials Science and Engineering faculty labs, its unique optical design provides complete and continuous wavelength coverage from 160 to 800nm. With every wavelength available, the FOUNDRY-MASTER has unmatched analytical flexibility. Optical micrographs were realized to determine alloy microstructure using a Weiss microscope design with a computer connection. The dilatometric tests for material behaviour at heating process was made using a differential dilatometer type Linseis L75H which have some few special characteristics as: samples can be expose to heating or cooling depending of case, with or without linear regime, the sample temperature can be measure until 2050 ºC using a thermocouple or with a pyrometer (by radiation) until 2400 ºC and tests can be made in air , vacuum or inert gas. With this equipment can be made next measurements:

- relative change or modification of sample length expose heating-cooling process
- dilatation linear coefficient
- transformation points

- tested material density modification
- contraction
- penetration
- thermal dilatation

The main component parts of this equipment are presented in next figure:

Figure 1. Dilatometer L75 with most important parts: command panel, heating oven and measurement head, data acquisition system connected to PC.

The most important technical specifications of this equipment are :

- temperature field -150 to 500, 1000, 1400, 1600 ºC
- heating rate 0,1 la 50 ºC by minute
- measurement dimensions ±25 – 2500 µm
- maxim vacuum 10^{-5} mbar
- accuracy ±1% for hole scale
- repeatability ± 150 nm
- resolution ± 0,125 nm /digit

3. Results and discussions

In this study was trace the stabilization of an alloy Al-Si after 4 heating-cooling cycles by registered of dilatation variation on the same material and in the same experimental conditions. Chemical composition of the investigated alloy is presented in figure 2.

Foundry-Master 01J0013 Optik 01J0013
Sample : aluminiu piesa
Alloy : AL_000 Mode :PA 2/26/2008 10:16:10 AM

	Al	Si	Fe	Cu	Mn	Mg	Zn
1	82.5	13.1	0.772	1.92	0.221	0.143	0.836
Average	**82.5**	**13.1**	**0.772**	**1.92**	**0.221**	**0.143**	**0.836**

	Cr	Ni	Ti	Be	Ca	Li	Pb
1	0.0177	0.0817	0.0309	< 0.0001	0.0031	< 0.0001	0.116
Average	**0.0177**	**0.0817**	**0.0309**	**< 0.0001**	**0.0031**	**< 0.0001**	**0.116**

	Sn	Sr	V	Na	Bi	Zr	B
1	0.0986	< 0.0001	0.0065	0.0036	< 0.0050	0.0044	0.0006
Average	**0.0986**	**< 0.0001**	**0.0065**	**0.0036**	**< 0.0050**	**0.0044**	**0.0006**

	Ga	Cd	Co	Ag
1	0.0090	0.0021	< 0.0030	0.0029
Average	**0.0090**	**0.0021**	**< 0.0030**	**0.0029**

Figure 2. Chemical composition of an Al-Si alloy realized with a spectrometer.

The investigated alloy structure is present in figure 3.

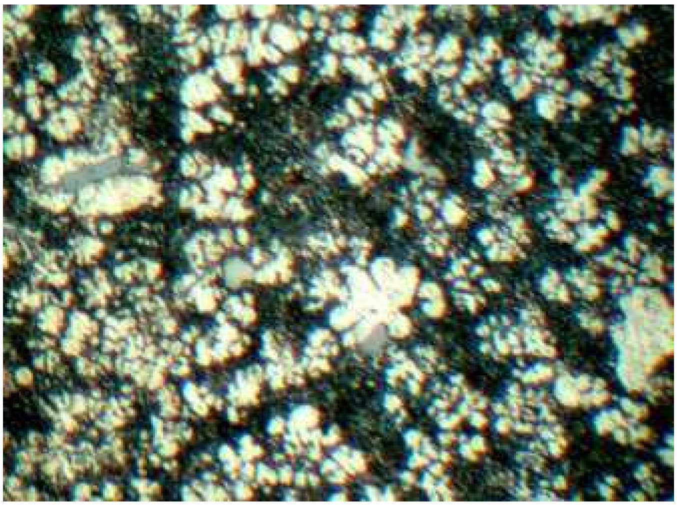


Figure 3 Metallographic imagine of alloy structure Al-Si used as bush for aero spatial application

The sample was subject of a stabilization thermal treatment which consist of heating the sample until 350 º C main tended for 2 hours fallow by a cooling in the furnace until 200 ºC and after that cooling in air until room temperature. After was applied a treatment of ageing by heating the sample until 250 ºC time of 12 hours follow by a cooling in water.

Structure of alloy after those two thermal treatment applied is presented in next figure.

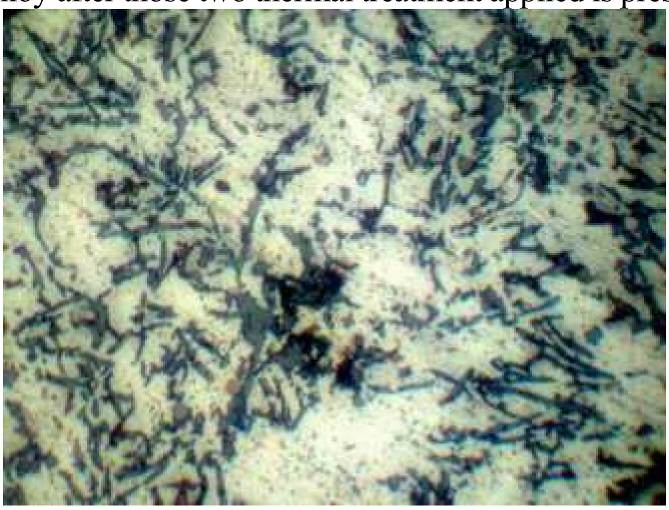


Figure 4. Micrograph of alloy Al-Si after the thermal treatments applied

A sample from alloy was mechanical prepare for dilatometric analyze and have the geometrical dimensions from the figure, a special request being the edges of sample which must be very flat and right to eliminate errors from data acquisition of dilatation registration. In this study ware investigated parallelepiped and cylindrical samples with the same main dimensions.

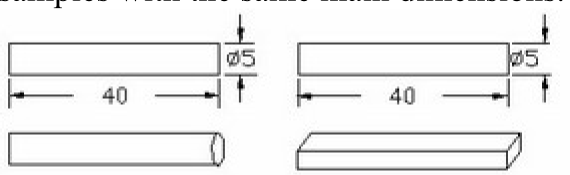


Figure 5. Sample scheme used in dilatation tests.

Tests realized on Linseis L75 dilatometer using a parallelepiped sample with length of 40.59 mm and width of 50.6 mm setting a heating rate of 10 ºC/minute until a 350 ºC temperature. In table 1 are presented the temperature values for furnace and sample registered minute by minute from the command panel of equipment.

Table1. Heating temperature variation for furnace and sample during dilatation test

Time [min]	**Sample temperature [ºC]**	**Furnace temperature [ºC]**	**Time [min]**	**Sample temperature [ºC]**	**Furnace temperature [ºC]**
0	22	27	**21**	233.8	326
1	23.2	57,6	**22**	244	333
2	24.7	83,4	**23**	250	340
3	27.6	112,5	**24**	262	349
4	33.9	141,6	**25**	270	357
5	41.3	171,6	**26**	279	367
6	51.4	195,6	**27**	288	376,8
7	61.2	215,6	**28**	297	386
8	73.1	234,4	**29**	306	396
9	87.4	250	**30**	317	405
10	100.2	262	**31**	326	414
11	118.5	270	**32**	337	427
12	130	279	**33**	345	431
13	144.7	285	**34**	348	435
14	164.6	295	**35**	**352**	436
15	174.6	300	**36**	356	426
16	188.4	305,3	**37**	361	409
17	192.7	308	**38**	367	367
18	201.6	310	**39**	358	341
19	216.8	315	**40**	343	320
20	226	321	**41**	332	301

From data analysis is observe the thermal inertia cause of passing the set temperature of 350ºC reaching a maximum value of 367 ºC. In this time when sample reach value of 350ºC for temperature the heating source, thyristor based, stopped and in that moment the furnace have a 436 ºC temperature and after this the cooling system, with a 10 l/minute flux, help in cooling process of the sample.

Forwards are present graphically the increasing temperatures of furnace and sample during the heating test inside the differential dilatometer.

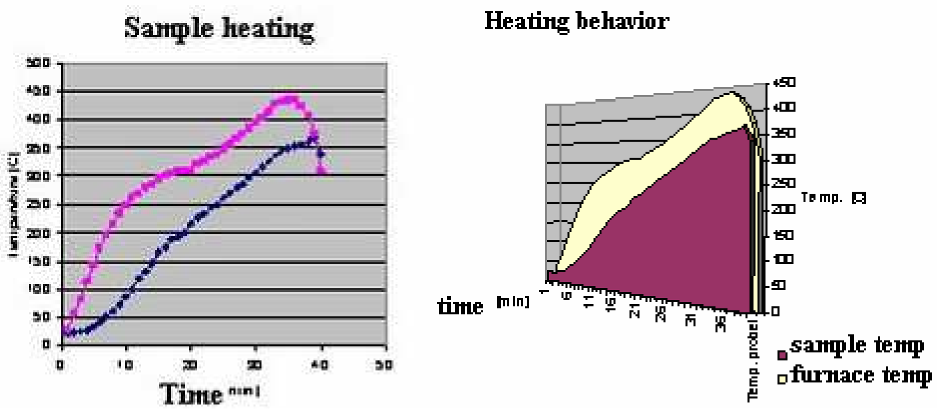


Figure 5. Heating graph of a cylindrical Al-Si alloy length 50.6 mm and diameter of 5 mm.

The heating sample temperature was set until 350 ºC with a heating rate of 10 ºC/min. Using this two graphics we can determinate a setting temperature for furnace or sample with respect for thermal inertia so we can control the temperature in sample very good like 2-5 °C variation. In this sense, conforming to diagrams, for a set temperature of 350 ºC, the sample will reach 367 ºC, practically we need to set the equipment to heat the sample at 337,5 ºC to obtain a need temperature of 350 ºC.

The dilatometry test realized on investigated Al-Si alloy presents next result, a 180 µm dilatation at 350ºC (figure 6).

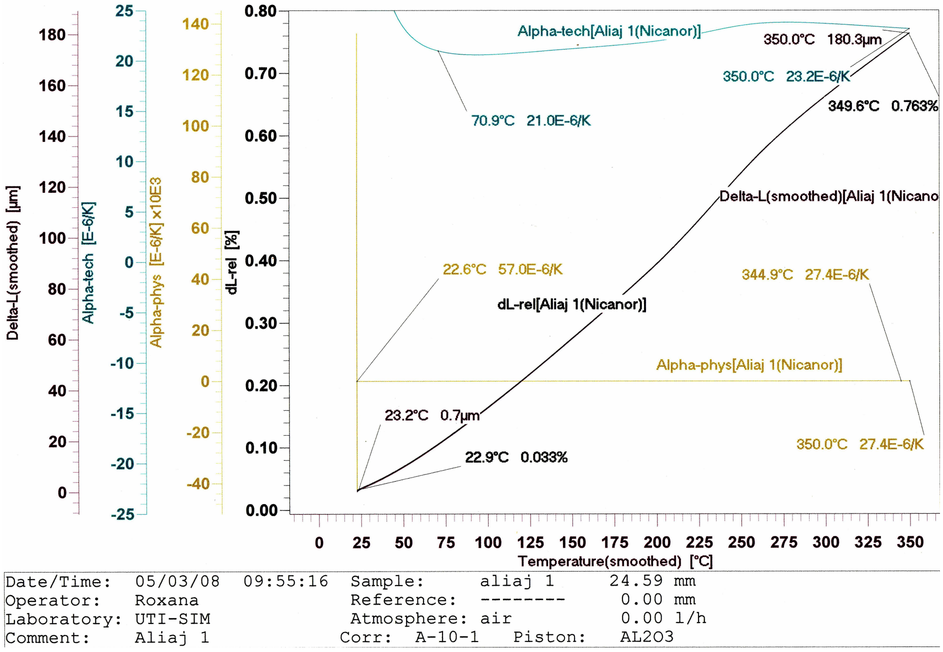


Figure 6. Dilatogram realize with Linseis equipment by heating the sample until 350 ºC, using a rate of 10 ºC/min.

To realize a study about thermal stability we repeat 4 times the dilatation test and the results are present in figure 7.

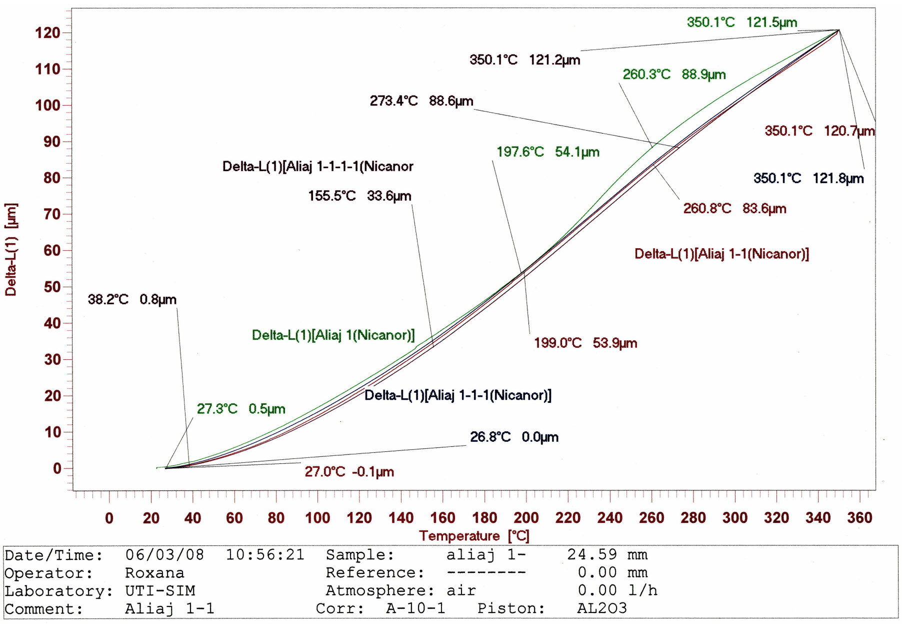


Figure 7. Dilatogram of four heating cycles for Al-Si alloy.

In next figure is presented a dilatogram of four heating cycles until 350 ºC with a rate of 10 ºC/min for Al-Si alloy sample thermal treated:

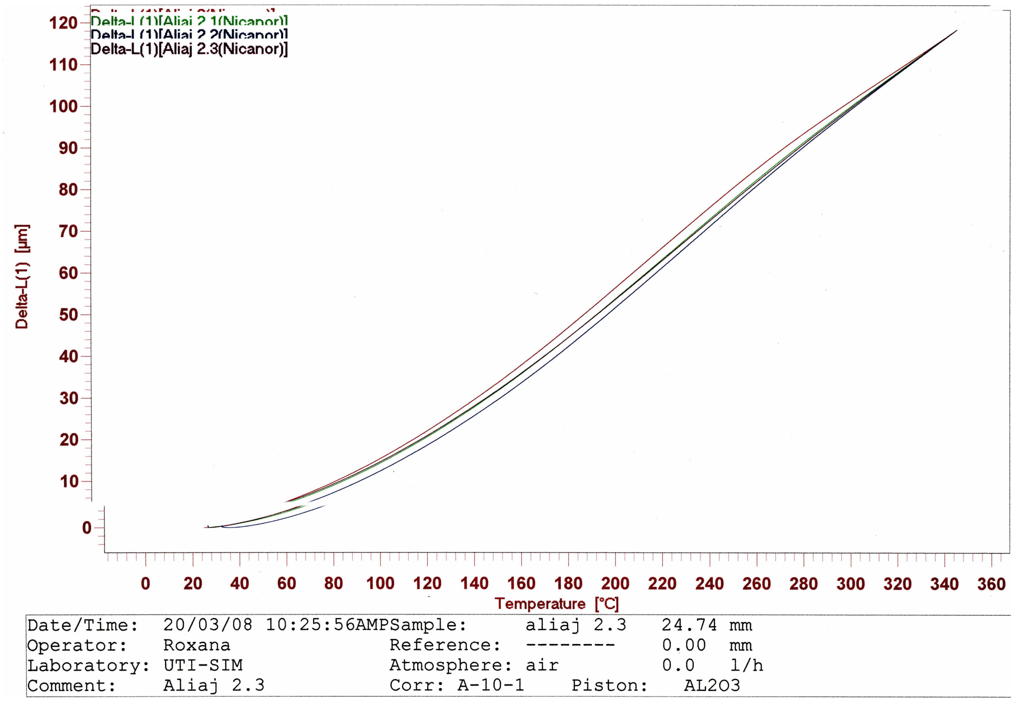


Figure 8. Dilatogram of four cycles for a thermal treated sample.

4. Conclusions

- analyzing the thermal transfer between the dilatometer furnace and inside him sample we can establish for any material investigated a heating schedule so we can obtain controlled temperatures very closed to those desired with respect for sample dimensions and thermal inertia of furnace.
- after two or three heating cycles the based Al-Si alloy suffer a thermal stabilize, conforming to diagram presented in figure 7m dilatation being of 121.5 µm for first heating cycle and after that 120.7 µm for all next three tests, values are registered at 350 ºC with a rate of 10 ºC/min.
- thermal treatment describes above in paper improve the material behaviour at thermal cycles reducing the differences between first and next heating cycles.
- dilatometer capacity to realize heating cycles setting a finite cooling rate and heating parameters help the determination of a material behaviour subject of repeat heating cycles.

Received November 30, 2008 *Technical University "Gh. Asachi" Iaşi*

REFERENCES

1. Alten D.G., Kaufman J.G., **Aluminum Technology, Applications and Environment**: **A profile of a modern metal**, Published by Minerals, Metals and Materials Society USA, 1998
2. Hatch J.E., **Aluminum Properties and Physical Metallurgy,** Published by ASM International, 1984.
3. Farndor J., **Aluminum,** Published by Marshall Cavendish, UK, 2001.

STUDIUL DILATĂRII MATERIALELOR METALICE PE BAZĂ DE ALUMINIU CU AJUTORUL DILATOMETRULUI

Rezumat: Un aliaj pe bază de aluminiu-siliciu a fost investigat în vederea stabilirii stabilității sale termice cu ajutorul dilatometrului. Aliajele pe bază de aluminiu datorită proprietăților lor deosebite sunt utilizate în diverse ramuri industriale cum ar fi aeronautica ca elemente uşoare dar în acelaşi timp cu bune proprietăți ce aparțin materialelor metalice. Aliajele au fost investigate cu ajutorul unui spectrometru cu scânteie pentru determinarea compoziției chimice, microscopia optică a aliajului s-a realizat pe un microscop cu cameră foto de laborator iar comportamentul la încălzire a fost determinat prin dilatometrie.