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RESEARCH REGARDING THE INFLUENCE OF THE SHEET CHEMICAL COMPOSITION ON THE STRAIN TRACTION

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ABSTRACT

The chemical composition of the metallic material influences the mechanical characteristics of the material from which it is part. The paper studies the modality in which strain traction is influenced by the main chemical components which form, besides iron, the structure of the sheet.
The researchers followed to obtain a dependence equation that can be used to appreciate the strain traction with the help of chemical composition. Another part of the study wants to establish the most important chemical element from the sheet composition that have the main influence in appreciation of the strain traction.

KEYWORDS: chemical composition, tensile test, breaking strength

1. THEORETICAL HYPOTHESIS

Knowledge of the conditions under which the material passes during processing from the status of elastic state to plastic presents importance in the analysis of the deformation processes [1].

In the case of traction – uniaxial tensile, the passage from the elastic state to the plastic state occurs when strain exceeds the limits of the material’s flow.

The appreciation of the ability of deformation for thin steel plates can be carried out on the basis of their mechanical properties: yield limit R_e, breaking strength R_m, breaking elongation, necking ratio, properties determinate by tensile tests [2].

For the plastic deformation process a specific tensile strain is necessary in the structure of the material.

The deformation strength of the material can be appreciated using the value of breaking strength R_m, Equation 1, where: F_m is the maximum value supported by the sample before breaking; S_0 is the initial area of the sample in the calibrated zone.

$$R_m = \frac{F_m}{S_0}\,[N/mm^2] \qquad (1)$$

In this paper we have studied the influence of the chemical composition of the thin steel sheet, heated and non-heated on the breaking strength R_m. During this study we have also followed the elaboration of a mathematical model between tensile resistance and the chemical composition of the sheet that has been tested.

Knowing the chemical composition allows us to establish mathematical models which can help determine the mechanical parameters without performing the tensile test.

The dependence relationships between the followed parameter breaking strength R_m on one side and on the other the influence factors (carbon, manganese, silica, sulfur, phosphorous and aluminum) as well as the relationships between the influence factors constituted as a group of factors, determine the dependences which can be studied with the Equation 2, equation which allows the determination of the maximum number *N,* of possible dependences, where, *n* is the number of influence factors [3].

$$N = n + \left(2^{n-1} - n - 1\right) + \frac{n\cdot(n-1)}{2} + n\cdot\left(2^{n-1} - n\right) + \left(2^{n-2} - n + 1\right) \qquad (2)$$

Determining the maximum number of possible dependences shows that, with the growth of the influence factors, there is also a growth in the complexity and in the number of possible dependences.

Furthermore the study has followed the optimization of the influence factors (the chemical compounds of the sheet) determined through the correlation analysis which permits the establishment of static links between these factors. The procedure involves the determination of the coefficients of odd correlation, between each two influence factors, using the obtained experimental data [4].

The usage of graph analysis only allows the calculus of the existent links between the influence factors, but does not take into account the correlation coefficients. The next step in analyzing the correlations is to establish the most general influence factors, from the ones that have been studied, which means taking into consideration of the absolute values of the calculated coefficients. The degree of influence of the tip of the graph must be determined, with the help of the number of edge that come out from the tip.

In order to prove that *n* is the most influent tip, we have examined, as an associated matrix, the matrix of the correlation coefficient.

2. PROCESSING OF THE EXPERIMENTAL DATA

The experimental researches were made on 24 samples from special steel use in drawing processes. The samples were extracted from the sheets with the same thicknesses.

The tensile tests were made on Tinius-Olsen equipment with the force area between 3 kN and 150kN. A strain gauge type Epsilon 3542-050 M-020-ST, B1 class was used.

The elongation speed was constant. The nature of the material composition was not taken into account.

For the study of this influence we have analyzed 24 sets of data obtained after eliminating the values affected by errors [5]. The numerical limits of the chemical composition for the thin sheets of steel studied are given in Table 1 and those of the determined parameters after the tests in Table 2.

Tabel 1. Numerical limits of the chemical compound.

Numerical Limits	Chemical composition, %					
	C	Mn	Si	S	P	Al
Minimum	0,03	0,2	0,005	0,009	0,006	0,016
Maximum	0,08	0,5	0,05	0,018	0,028	0,097

Tabel 2. Numerical limits of the determined parameters

Numerical Limits	Determined parameters		
	R_e [N/mm^2]	R_m [N/mm^2]	A_{80} [mm]
Minimum	189	324,5882	34,74
Maximum	254,2	371	40,05

Application of the statistic method follows to obtain a mathematic model which would express more faithful the nature of the dependence.

After the static processing and the obtained data analysis, we have established throughout the studied parameters, the following types of regression equations.

- linear type, Equation 3;
- exponential type, Equation 4;
-

$$R_{mL} = 301,286 + 241,456 \cdot [\%C] + 67,421 \cdot [\%Mn] - 29,934 \cdot [\%Si] + 554,052 \cdot [\%S] + 448,882 \cdot [\%P] - 114,077 \cdot [\%Al] \quad (3)$$

$$R_{mE} = 450,499 \cdot [\%C]^{0,028} \cdot [\%Mn]^{0,068} \cdot [\%Si]^{-0,004} \cdot [\%S]^{0,015} \cdot [\%P]^{0,023} \cdot [\%Al]^{-0,013} \quad (4)$$

The intensity of the link between R_m and the independent parameters – the elements of the chemical composition, is given by the multiple correlation coefficient, R. The percentage with which it influences in the same time the independent parameters from each equation on the R_m characteristic, is given by the coefficient of multiple determination, R^2.

The values of the determination coefficient and of the correlation coefficient belonging to the two types of regression equations are represented in Table 3. From the analysis of these values Equation 3 has been obtained, of linear type, which offers the best mathematical representation for the determination of the R_m characteristic depending on the chemical compound of the thin sheet of steel for deep drawing because the value of the multiple correlation coefficient, R=0,762951 is higher then in Equation 4.

The value obtained for R^2 shows that the chemical compounds which have been studied influence in the same time with a percentage of 58,20% the R_m characteristic.

Table 3. The values of the indicators determination coefficient and multiple correlation coefficient

Indicator Type	Specific value of the model	
	$R_{m\,L}$	$R_{m\,E}$
R^2	0,582095	0,572147
R	0,762951	0,756404

The multiple correlation coefficient indicate the existence of strong links between and the chemical compounds from the studied sheet.

The precision of the regression equation of linear type is expressed through the values of the following indicators:

- s = 8,85854, which explains the fact that the regression equation of linear type has the smallest value of the medium quadratic residue;
- C_v % = 2,586746 %, which indicates the existence of a small variation between the

experimental values an the ones calculated with the linear type regression equation.

We have verified using the Fisher test the significance of the nonlinear correlation coefficient for the linear type equation and we have obtained: $F_c = 5,571549 > F_{critic} = 2,51$, the nonlinear correlation coefficient is significant for a signification level of $\alpha = 0,05$ and the number of degrees of freedom $\nu_1 = 6$ şi $\nu_2 = 24$.

Next we have tested the significance of the coefficients of the linear type regression equation with the help of the Student test.

The test results for $t_{0,05;\,24} = 2,064$ show that:

$$|a| = 301,28659 > |\Delta a| = 2,69721$$
$$|b_1| = 241,45612 > |\Delta b_1| = 32,78633$$
$$|b_2| = 67,42118 > |\Delta b_2| = 7,471079$$
$$|b_3| = 29,93408 > |\Delta b_3| = 5,906242$$
$$|b_4| = 554,05280 > |\Delta b_4| = 173,4063$$
$$|b_5| = 448,88214 > |\Delta b_5| = 97,75098$$
$$|b_6| = 114,07772 > |\Delta b_6| = 27,01693$$

It can be see that the absolute value of the coefficients *a* and b_i (i = 1...6) is superior to the trust interval of these coefficients, although these coefficients are insignificant.

After applying the Fisher test in order to verify the accuracy of the model of exponential type we have obtained $F_c = 1,717933 < F_{critic} = 1,840871$, the model is accurate.

The optimization of the influence factors has been realized through the correlation analysis which allows a statistical link between these factors [6]. The obtained results following the determination of the correlation coefficients between the chemical compounds of the composition and the obtained results obtained from de calculus of the iterations are given in Table 4.

The graphs of the correlation links for the trust probabilities P=95% and P=99% are represented in Fig. 1.

Table 4. The value of the correlation and iteration coefficients

Chemical Composition							First iteration		Second iteration	
	C	Mn	Si	S	P	Al	$p^i(1)$	Place	$p^i(2)$	Place
C	1	0,453**	0,024	-0,294	0,342	0,246	1,452	2	2,283	2
Mn	0,453**	1	-0,013	-0,221	0,383*	-0,092	1,835	1	3,023	1
Si	0,024	-0,013	1	-0,146	-0,13	-0,143	1	4÷6	1	4÷6
S	-0,294	-0,221	-0,146	1	-0,29	-0,014	1	4÷6	1	4÷6
P	0,342	0,383*	-0,126	-0,287	1	-0,033	1,383	3	2,086	3
Al	0,246	-0,092	-0,143	-0,014	-0,03	1	1	4÷6	1	4÷6
**Is important until 99% * Is important untill 95%										

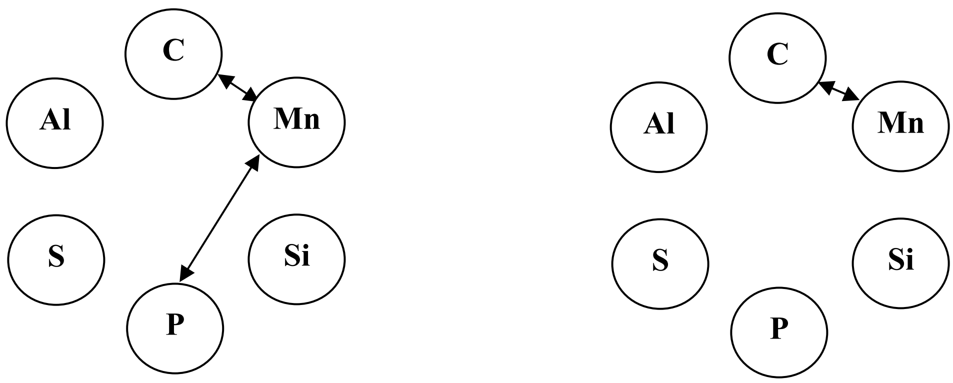

Fig. 1. The graphs of the correlation links for:
a) a trust probability of 95%; b) a trust probability of 99%

3. CONCLUSIONS

From the analysis of the dependence equation (2) it can be observed that the chemical compounds influence in a different way the breaking strength R_m, like this:

- carbon, manganese, sulfur and phosphorous influence in an ascending way;
- silica and aluminum influence in an descending way;

From the importance point of view, the factors that influence can be ordered like this: *Mn, C, P* and *Si, S, Al*.

From the graph analysis it can be observed that the *Mn* has the biggest influence because of the links established with the other chemical compounds. For P=95%, *Mn* has two links and for P=99% has only one link. Between the other elements from the chemical compound there are no obvious correlation links for trust probabilities larger than 95%.

The graph theory at which the calculus of iterate force is added gives us the conclusion that, from the chemical elements studied, *Mn* is the element with the highest degree of influence on R_m.

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