ACTA TECHNICA CORVINIENSIS
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[1.] AMALIA ANA DASCĂL

STUDY ON THE VARIATION OF CONVENTIONAL FLOW LIMIT DEPENDING ON THE MAIN ALLOY ELEMENTS FOR THERMORESISTANT STEEL

Abstract:
The paper presents the results of the research made under laboratory experimental testing, on OLT45K steel, intended to the manufacturing of tubes, used at high temperature in the make-up of thermal-energetic installation. Mechanical driving testing has been made at the temperature of 450°C, on shares of test-bars drawn out of a number of 50 charges, with a view to achieving the optimization of the chemical composition of this steel type. The optimization, under experimental dates, suggests alternatives of combinations among the main elements of the chemical composition, so as the steel can be elaborated with superior mechanical features at high temperature. The obtained results have a large feasibility area, and can be also endorsed for other steel types and mechanical features for which the optimization is viewed, therefore being very useful to technologists, in the process of achieving a certain type of steel.

Keywords:
high temperature, thermal resistant steel, mechanical testing, life-length, mechanical feature

GENERAL APPRECIATION

Generally, any research elaboration implies some stages: gathering the dates, their modeling and the decisional working out. The informational pattern-making follows 3 steps: manual, mechanical and automatic.

Its results have to be presented in a shape which makes them utilizable by the beneficiary, no matter the pattern-making method.

A new and important problem, raised in the study of multidimensional reparations, concerns the bound among the analyzed variables and through them, among the phenomena they represent, known as correlation. It includes two fundamental problems: the first consists in describing the medium variation law of a variable depending on another (or other) variable(s), known as the problem of regression and settled under the regression function, and the irrespective of the linked variable measures.

Estimating and sizing the thermal-electric power station pipes is extremely detailed and expensive, regarding the use of the finite element programmes, as it is very hard to specify all the testing which the pipe system is to be requested, during the estimated life length. Extreme situations and possible exploitation accidents are also hard to estimate.

This is the reason of choosing as a subject of the paper the making of multiple correlations, II figure, which offers information on the influence of two of the chemical composition elements on the technical running limit at the temperature guaranteed by the metal manufacturer. From the graphical representation and knowledge of the *outline values, we can establish the desired value of the mechanical feature, for any content of an element found in the chemical composition. We can also establish the best variation fields of these elements, varying with the desired values of the studies parameter.*

EXPERIMENTAL DATES

The numerical studies had as starting point the driving experimental testing at heat, made on shares of test-bars drawn out of a number of 50 charges of OLT 45K steel, endorsed into an electrical oven equipped with a spring, whose chemical composition is presented in [1] paper.

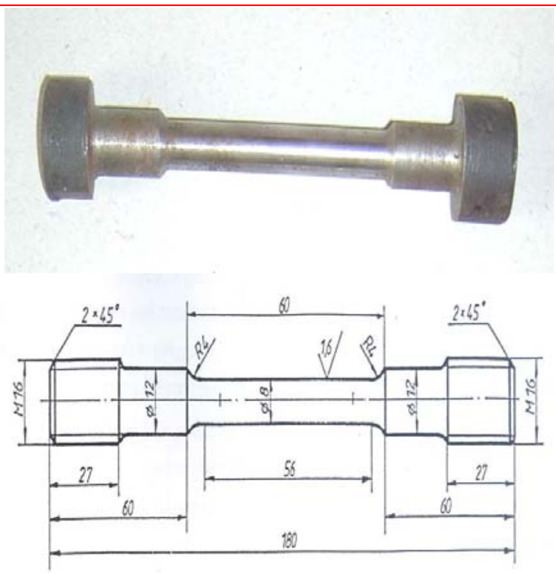

Fig.1 The shape and size of test-bars used in testing

Three test-bars have been tried for each charge, their shape and size being shown in fig.1.

ESTABLISHING THE NUMERICAL STUDIES

By using the experimental dates obtained after laboratory testing, it went forward to establishing some graph correlations, using MATLAB 5.0 programme. Files with experimental dates and those obtained by the rolling of the used programmes, can be found in [1] paper. The numerical results, obtained by rolling the programme are sizable, for which they are not presented in the paper. Then, the graphs obtained by mathematical pattern-making of the results.

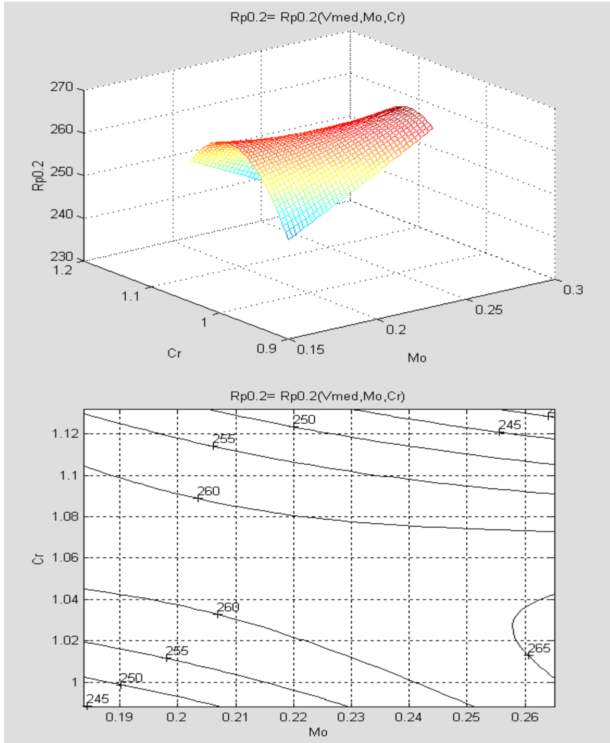

Fig.2 The variation of the technical running limit $R_{p0.2/450}$, containing manganese and silicium, taking into consideration the medium percentage of carbon

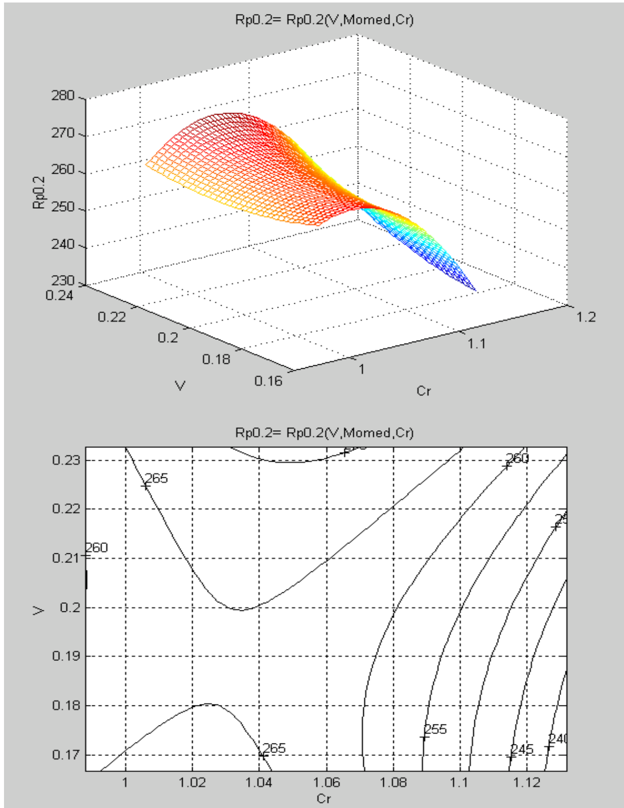

Fig.3 The variation of the technical running limit $R_{p0.2/450}$, containing carbon and silicium, taking into consideration the medium percentage of manganese

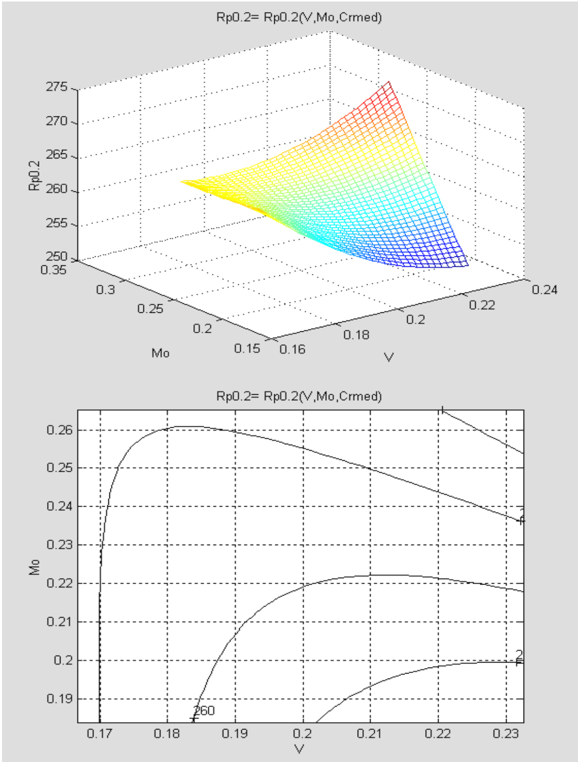

Fig.4 The variation of the technical running limit $R_{p0,2/450}$, containing manganese and carbon, taking into consideration the medium percentage of silicium

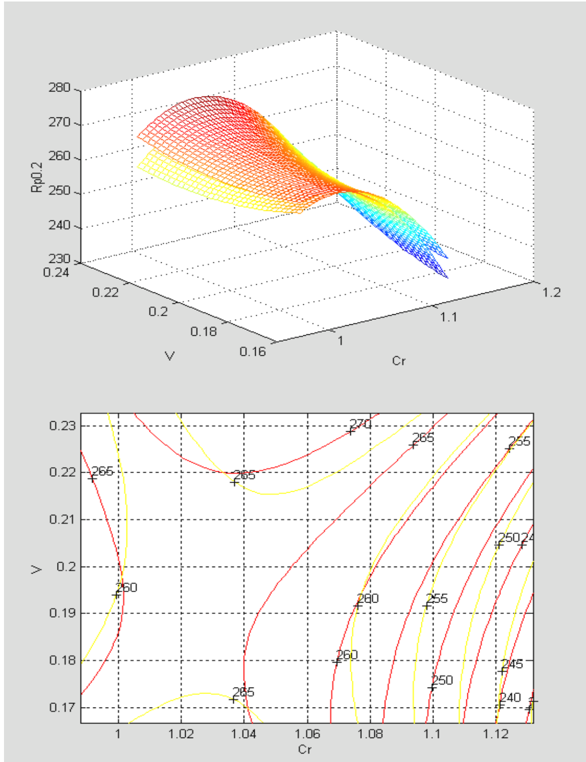

Fig.6 The delimitation of the best field for the technical running limit $R_{p0,2/450}$, depending on the carbon and silicium content, taking into consideration the medium percentage of manganese

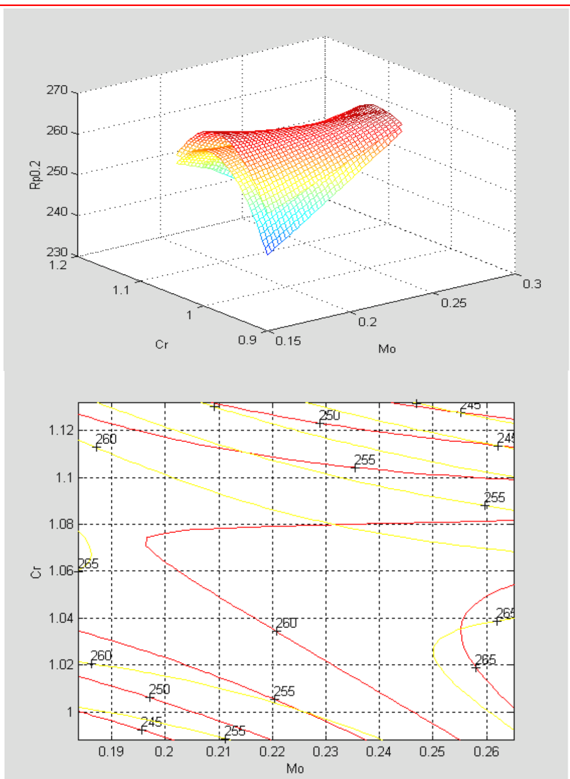

Fig.5 The delimitation of the best field for the technical running limit $R_{p0,2/450}$, depending on the manganese and silicium content, taking into consideration the medium percentage of carbon

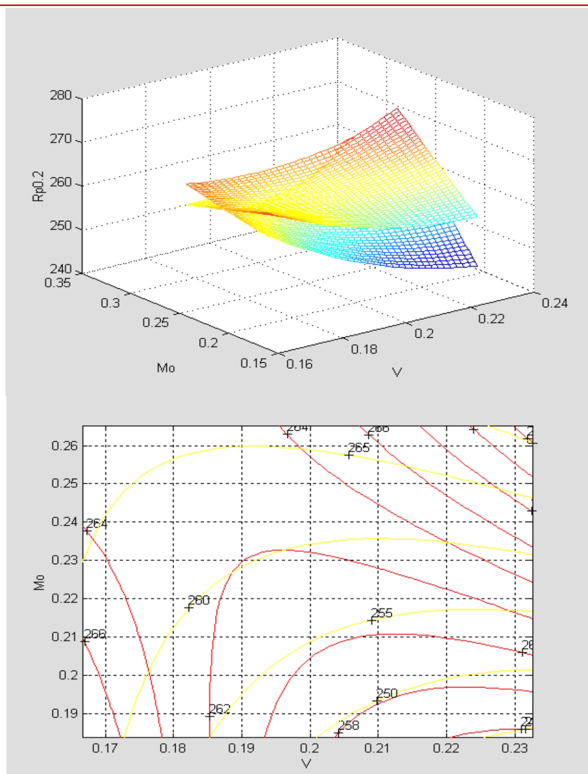

Fig.7 The delimitation of the best field for the technical running limit $R_{p0,2/450}$, depending on the carbon and manganese content, taking into consideration the medium percentage of silicium

Because of the huge size of dates found in such a processing of experimental dates, we stopped, focusing on the mechanical feature $R_{p0,2/450}$, which must be guaranteed by the metal manufacturer, for the analysed steel.
The most important feature of this steel category at high temperature is the conventional running limit at heat. This is the reason why the study has been made for establishing combinations of the best chemical composition and through the working process, for the steel to have superior mechanical features. Therefore, the obtained results follow the way of the conventional running limit for combinations of three main elements of the chemical composition. Through the multidimensional numerical pattern-making of the experimental dates, it was tried the finding of a modeling of the dependent variable, considering the independent variables x, y, z as:

$$u=C_1\cdot x^2+C_2\cdot y^2+C_3\cdot z^2+C_4\cdot x\cdot y+C_5\cdot y\cdot z+C_6\cdot z\cdot x+C_7\cdot x+C_8\cdot y+C_9\cdot z+C_{10} \quad [1]$$

The variation limits of the variable are:

[%C] = 0,16…0,23; [%Mn] = 0,51…0,83; [%Si] = 0,16…0,35; $Rp_{0,2/450}$ = 169…255.

The medium values and the medium square deviation of the variables are:

[%C]:0,18563…0,01886; [%Mn]:0,66375…0,09545; [%Si]:0,235…0,047697; [$Rp_{0,2/450}$]: 08,95…17,193

The correlation coefficient is valued:

rf = 0,65599451703118,

and the deviation from the regression area is:

sf = 12,97668845383391

The maximum established on the 50 charges sample is given by:

$$R_{p0.2}=19828{,}0654\cdot[\%C]^2-268{,}3624\cdot[\%Mn]^2+571{,}8135\cdot[\%Si]^2-2984{,}07\cdot[\%C]\cdot[\%Mn]+148{,}8591\cdot[\%Mn]\cdot[\%Si]+1182{,}9936\cdot[\%Si]\cdot[\%C]-5668{,}4577\cdot[\%C]+962{,}9562\cdot[\%Mn]-672{,}8277\cdot[\%Si]+472{,}3753 \quad [2]$$

These 4 dimensional surfaces allow a saddle point of coordinates:

[%C] = 0,19417; [%Mn] = 0,79343; [%Si] = 0,2842; Rp0,2/450 =208,473.

The existence of the saddle point is very important as it assures a stability of the feature close to this point, being it preferable or avoidable. In this case, it is preferable. The behavior of these hyper surfaces close to the saddle point can only be studied as tabular, which means ascribing values on concentric spheres of the studied point to the independent variable. Because of the fact that this surface cannot be represented in 4 dimensional spaces, it has been chosen the successive replacement of each independent variable, with its medium value, and obtaining the following equations:

$$R_{p0.2}C_{med}=-268{,}3624\cdot[\%Mn]^2+571{,}8135\cdot[\%Si]^2+148{,}8591\cdot[\%Mn]\cdot[\%Si]+409{,}0382\cdot[\%Mn]+453{,}2345\cdot[\%Si]+103{,}3764 \quad [3]$$

$$R_{p0.2}Mn_{med}=571{,}8135\cdot[\%Si]^2+19828{,}0654\cdot[\%C]^2+1182{,}9936\cdot[\%Si]\cdot[\%C]-74{,}0225\cdot[\%Si]-7649{,}1341\cdot[\%C]+993{,}3067 \quad [4]$$

$$R_{p0.2}Si_{med}=19828{,}0654\cdot[\%C]^2-268{,}3624\cdot[\%Mn]^2-2984{,}07\cdot[\%C]\cdot[\%Mn]-5390{,}4542\cdot[\%C]+997{,}938\cdot[\%Mn]+345{,}8392 \quad [5]$$

These surfaces which belong to the 3 dimensional spaces can be represented and therefore interpreted by technologists. The surfaces are shown in fig.2, fig.3, fig.4, fig.5, fig.6 and fig.7. For a more exact analysis, the corresponding level curves have been shown next to these. The knowledge of the level curves allow the establishing of the two independent variable values, so as $R_{p0,2/450}$ can be obtained, within the limits required or imposed by the beneficiary.
By looking at the graphs shown in fig.2, and considering %C an average, you can estimate that maximum values of $R_{p0,2/450}$ feature can be obtained for 0,50% Mn and 0,14% Si, values which are close to the inferior limit of the composition imposed by standard. From fig.3, considering % Mn an average, you can say that maximum values of $R_{p0,2/450}$ (230 N/mm²) features can be obtained for C concentrations within the 0,12 – 0,14% limits and Si within the 0,15 – 0,18% limits, subfields which are close to the inferior limit of the composition imposed by standard. From the graphs shown in fig.4, and considering % Si an average, you can estimate that while the C and Mn grow, the $R_{p0,2/450}$ conventional running limit grows as well. The diagrams in fig.5, fig.6

and fig.7 show the limits of the maximum field, where the metallurgic engineer can choose the element percent of the chemical composition, in order to obtain steel having the desired features of the manufacturer. Knowledge of the level curves for these maximum fields allows the correlation of the two independent variable (the contents of the chemical element) so that $R_{p0.2/T}$ can be obtained within the limits asked by the beneficiary.

CONCLUSION

These results allow the establishing of the best C, Mn, Si contents from the chemical composition of 12VMoCr10, so that, by the end of the elaboration, steel can possess certain imposed mechanical features.

The analysis has been done for 3 elements of the chemical composition, being able to enlarge it for both other elements, depending on the desired chemical composition and other types of steel.

Taking into consideration that the way in which one charge is done has a deep importance on the mechanical features of the steel, knowledge of these correlations is really significant for the engineer, because he is the one to estimate the values of the imposed parameter, depending on the chemical composition which allows him the adjustment of the chemical composition during the elaboration, in order to obtain the features desired by the beneficiary.

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AUTHORS & AFFILIATION

[1.] AMALIA ANA DASCĂL

[1. 2. 3] DEPARTMENT OF ENGINEERING & MANAGEMENT,
FACULTY OF ENGINEERING HUNEDOARA,
UNIVERSITY "POLITEHNICA" TIMISOARA, ROMANIA

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UNIVERSITY POLITEHNICA TIMISOARA
FACULTY OF ENGINEERING HUNEDOARA
5, REVOLUTIEI
331128 – HUNEDOARA
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