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INCREASE OF MECHANICAL PROPERTIES OF LOW-ALLOY STEEL BY OPTIMIZATION OF HER CHEMICAL COMPOSITION

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Analysis of influence of chrome, vanadium and titan on mechanical properties of steel studied with the use of statistical method of planning of active experiment. As a function of response accepted tensile (Y_1) strength and limit of fluidity (Y_2). Mathematical processing of experimental data with the purpose of construction of mathematical model of influence of chemical composition on properties of steel conducted on methodologies [1] with the use of regressive analysis. For reduction of number of experiments supposing nonlinear character of functions of response in-process used a symmetric composition plan the second order.

As independent variables were chosen: maintenance in steel of chrome (X_1), maintenance in steel of vanadium (X_2), maintenance in steel of titan (X_3). In the process of search of optimal composition of alloy, in an induction stove with a basic lining-up by a capacity 50 kg it was the laboratory melting is conducted became. The got founding forged on purveyances measuring a 10x80x120 mm, with subsequent rolling in the hot state to the thickness 11 mm.

Calculation levels of intervals of varying, character of their changes and chart of encryption presented in a table 1.

Table 1

The Prospected factors

Description	Factors		
	Cr, m.%	V, m.%	Ti, m.%
Code	X_1	X_2	X_3
Basic level	0,15	0,15	0,15
Interval of varying	0,05	0,05	0,05
Bottom level	0,10	0,10	0,10
Top level	0,20	0,20	0,20

The choice of base-level and intervals of varying was conducted coming from that maintenance of carbon must be in the range of 0,08 - 0,12 m.%. It contingently: low bound - by the fall-off of durability; overhead - is a limit, the mass selection of fragile secondary phases begins after that, reduces plasticity of alloy.

A table of contents of chrome must be in the range of 0,05 - 0,15 m.%. It contingently the necessity of providing of formation of carbides for the wide interval of temperatures, that not insignificantly in the process of welding.

A table of contents of vanadium must be in the range of 0,05 - 0,15 m.%. It contingently: low bound - limit to his sufficient concentration for affecting structure and properties of alloy; top limit - by efficiency of his useful effect on braking of formation of carbides and nitride of iron.

A table of contents of titan must be in the range of 0,05 - 0,15 m.%. It contingently the decline of indexes of plasticity and shock viscidity, due to warning of formation of nitride, on leaving for the indicated limit.

Numeral values of coefficients regressions and their meaningfulness, certain taking into account distinction of dispersions for every function of response, and also t-test of meaningfulness and estimation of model adequacy, on the criterion of Fisher.

In the results of regressive analysis, the row of equalizations was got, showing dependence of tensile and limit of fluidity strength on maintenance of alloying elements.

As a result of calculations next equalizations were got in the encoded kind:

$$Y_1 = 406,4 + 42,1\,X_1 + 13,5\,X_2 + 3,06\,X_3 + 58,06\,X_1^2 - 0,72\,X_2^2 - 23,5\,X_3^2 +$$
$$+10,5\,X_1X_2 + 10,5\,X_1X_3 + 10,5\,X_2X_3 \tag{1}$$

$$Y_2 = 324,5 + 56,4\,X_1 + 19,3\,X_2 + 7,3\,X_3 + 82,5\,X_1^2 - 5,4\,X_2^2 - 27,6\,X_3^2 +$$
$$+7,25\,X_1X_2 + 7,25\,X_1X_3 + 7,25\,X_2X_3 \tag{2}$$

Coefficients the absolute value of that is equal to the confidence interval Δb or anymore it, it is necessary to confess statistically meaningful (Δb = 2,55). Statistically unmeaningful coefficients (in this case b_5 are equalizations (1)), it is possible to eliminate from models.

Verification of adequacy of models shows that they can be used for prognostication of values of functions of response at any values of factors being between overhead and lower levels. For this purpose it is expedient to pass to the natural variables:

$$\sigma_B = -150 - 7385Cr - 991V + 1627Ti + 23222Cr^2 - 9417Ti^2 + 4200CrV +$$
$$+4200CrTi + 4200VTi \tag{3}$$

$$\sigma_T = 55 - 9636Cr + 162V + 2586Ti + 32983Cr^2 - 2153V^2 - 11033Ti^2 +$$
$$+2900CrV + 2900CrTi + 2900VTi \tag{4}$$

For the estimation of adequacy of equalizations a calculation was conducted on the got equalizations of regression for base-level of chemical composition became. The results of calculations were confronted with experimental researches. It is set that an error between the calculation and experimental values of function of response does not exceed 5%.

With the purpose of determination of chemical composition, providing the receipt of optimal mechanical properties became, built three-dimensional graphic dependences (fig. 1 and 2).

Foremost, we will mark that all considerations about direction and force of influence of the studied factors on mechanical properties of steel it is possible to say of only for the intervals of their change chosen in-process. In these intervals it appeared notedly weak influence on mechanical properties maintenance of vanadium in itself, and also all double effects vanadium was included in that. On the whole, from all studied factors maintenance of vanadium can be counted, perhaps, same poorly influencing. Relative force of influence of other effects most easy to imagine on diagrams (fig. 1 and 2).
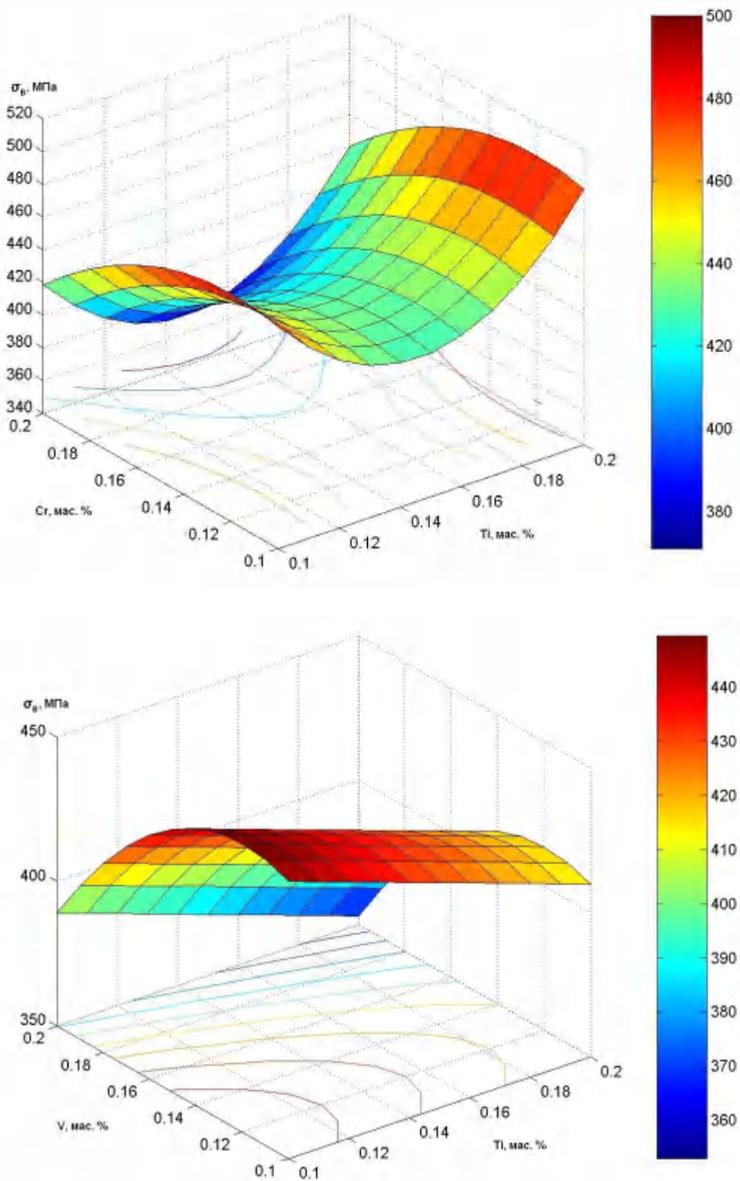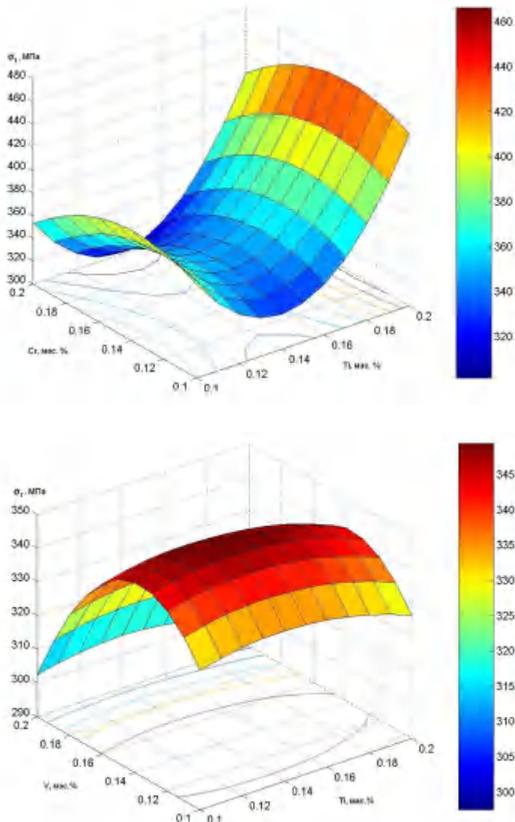
Fig. 1. Optimization of chemical composition became on tensile strength (σ_B)

Fig. 2. Optimization of chemical composition became on the limit of fluidity (σ_T)

From the analysis of fig. 1 and 2 evidently, that most strongly mechanical properties of steel depends on maintenance in steel of chrome and titan. Notedly a betweenness influences by the amount of chrome and titan. Presentation of results of experiment appeared the polynomial of the second degree to justified - considerable part of nonlinear members here meaningfully differs from a zero.

Conclusion

Recommendable optimal chemical composition became, m.%: carbon - 0,10 %, silicon - 0,31 %, chrome - 0,1 %, vanadium - 0,13 %, titan - 0,12 %. On the worked out chemical composition of steel the patent of Ukraine was got [2].

List of the used sources
1. *Новик, Ф.С.* Оптимизация процессов технологии металлов методами планирования экспериментов / Ф.С. Новик, Я.Б. Арсов. – М.: Машиностроение; София: Техника, 1980. – 304 с.
2. Позитивний висновок № 3872/ЗА/14, Україна, МПК С22 С38/28 (2006.1), Міщенко В.Г., Бєліков С.Б., Шейко С.П. та ін., замовник ЗНУ а 2013 09313.