PRESENTATION OF SOFTWARE FOR APPLYING SIMPLEX METHODS

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Abstract
This paper presents original software, developed for the needs of mathematical modeling of complex processes using the simplex method. The software was developed in the Delphi programming language for the Windows environment. The idea was to use the developed software to determine the efficiency of the simplex method in choosing the optimal mode of heat treatment of PdNi5 alloy, and simplex triangle can visually monitor the legality of the behavior of the test process depending on the influential parameters.
***Keywords**: Pd-Ni system, mechanical characteristic, Simplex method, optimization*

INTRODUCTION

The paper presents software, developed by the author of this paper, for the purposes of mathematical modeling of complex processes using the simplex method. The software was developed in the Delphi programming language for the Windows environment. The simplex method, also known as the Dantzig method, is one of the ways to find such a combination of interrelated factors (input, output and structural) that is the most favorable of a number of possible combinations. That is, such a combination is required which, in addition to satisfying the required limitations, will also satisfy the criterion of optimality of the goal function [1]. The basic concepts of the simplex method are geometric.The simplex method is a way to efficiently search for the vertices of the feasibility area (simplex) in order to find where the optimal value of the goal function appears. Simplex itself is a geometric figure in whose horns experimental points are placed. In a k-dimensional factor space, simplex is defined by k + 1 points in space. In the three-dimensional factor space, the experimental points are arranged in the prongs and at the top of the tetrahedron, while in the two-dimensional space, the simplex is a triangle, which in principle does not have to be equilateral. The lines connecting the corners are used exclusively to visualize the simplex. Simplexes can be defined for any factor space. Experiments in a factor space greater than three have no geometric representation. Then we talk about the "super-body" in whose horns the experimental points are placed and always the addition of one new point gives a new simplex [2]. Simplex-plans or simplex-lattices have been developed for the search of the experimental space, which are presented in the form of a concentration triangle (or tetrahedron) containing all experimental points, ie all possible combinations of factor levels [3,4]. The dependence of the results (system response) on the factor represents a surface in the spatial coordinate system. This surface is called the reaction surface or the responsive surface, because its shape is a reflection of the effect of factors. In the case of two factors, it can also be displayed in a plane. The aim of the research is not to find only the dependence of the response on the input factors of the system, but - the optimum. The reaction surface is unknown in most cases, so the research of the optimum is "touch in the dark" [2].

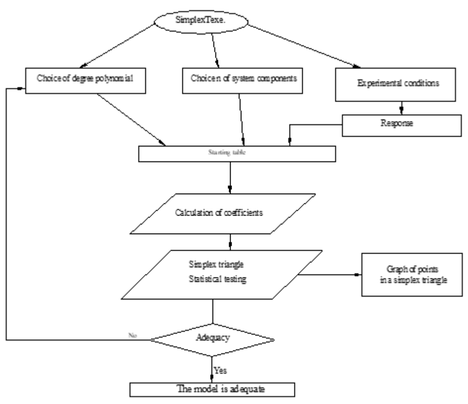

Figure 1. Block diagram of the SimplexT software program

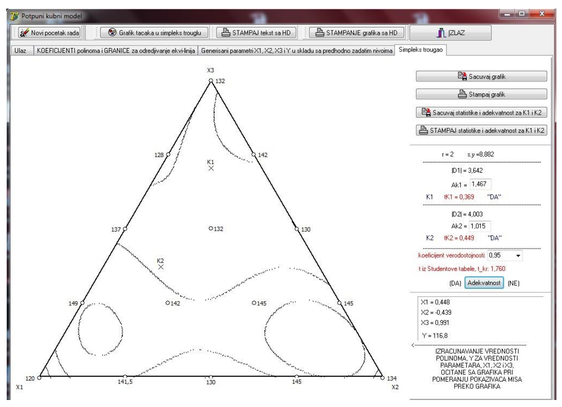

Figure 2. Graph of points in the Simplex triangle

EXPERIMENTAL AND DISCUSSION

The software developed in the Delphi software environment is presented here, with the help of which it is possible to perform mathematical modeling by the Simplex method, according to the theoretical considerations [1-4]. Namely, the intensive development of information technologies in recent decades has introduced the software in all areas of life, and thus in metallurgy. Using the developed software SimplexT in the Delphi software environment, it is possible to quickly and easily manage the processes and solve very complex problems in the field of applied and fundamental research in metallurgy in multifactorial experimental planning and modeling using the higher order polynomial functions. The used language in software is Serbian.

Figure 1 shows a block diagram of the SimplexT software program. The program is started by double-clicking on the generated SimplexT.exe icon and the program home page, appears on the screen. Selecting *the number of input factors* (a choice of two or three input factors is offered) and *order of the polynomial function* (second, third or fourth order), the software generates two tables: Table 1*_Experiment Plan Matrix* and Table 2*_Experimental Conditions.*

The field is shown within the Matrix of the experiment plan: the number of experiments as well as the fields that show the position of experimental points in space. The position of experimental points in space is determined so that the condition:

$$x1+x2+...+xq=1 \quad (1)$$

represents a regular simplex in the (q-1) _dimensional factor space. Therefore, the field of mathematical modeling using this software program is limited to the interval [0,1], which represents the coded values of influencing factors on the system response. In Table 2, the program user enters the real values of input factors as well as the experimental results. Based on two experimental results of repeated measurements, the software calculates the mean value (by clicking the button for calculation the mean values). There is no possibility of entering the mean values by the user. This re-reading of the experimental results for the same combination of input factors is performed in order to estimate the dispersion of results.

By selecting the option Polynomial coefficients and limits for determining the iso-lines, a box appears in which the software determines the polynomial coefficients by clicking the button_Calculating coefficients. The limits for determining the iso-lines (y from R_1; y from R_2) are filled by the software based on the minimum and maximum response values of the system for experimental points, while by selecting the steps (with step R_3), the density of iso-lines is chosen. Based on the calculated regression coefficients, a mathematical model in the form of a polynomial function can be formed according to the Scheffe approach. By selecting the ***Graph of points option*** in the ***Simplex triangle,*** the software generates a simplex triangle in which the iso-lines are shown (Fig. 2). The iso-lines in the simplex triangle represent lines of the same values of the observed response for different experimental conditions. By simply moving the mouse along the Simplex Triangle, it is possible to read from the Simplex Triangle the response values obtained by applying the generated mathematical model at points in the factor space where the experiment was not performed.

The model adequacy is assessed in the simplex control points, which are not taken into account in the calculation of regression coefficients when defining the model. The software assesses the model adequacy on the basis of value the Student t-criterion. The assessment results are obtained by clicking on the Adequacy button.

CONCLUSION

The following characteristics of the developed software can be highlighted:

- If some information about the investigated problem is known, there is a possibility of direct selection the appropriate form of the polynomial function, which can describe the system response.
- The process of mathematical modeling can be started by choosing a simpler form of polynomial function, with a further transition to more complex functions of higher order, until an adequate mathematical model is obtained.
- The number of factors that can be included in the consideration when defining the model can be chosen (two or three factors).
- There is no restriction on the type and nature of the factors chosen.
- The field of mathematical modeling is limited to the interval [0.1], which represents the coded values of influencing factors on the system response, while the real values of the factors can take any values that can be coded to a given interval by appropriate transformations.
- It is possible to construct the iso-lines in a simplex triangle, which represent the lines with the same system response value.
- After analyzing the legality of changes in properties originating from the same level lines, the optimal conditions for performing the experiment are selected, which enable to ensure an adequate response of the system.
- After the calculated numerical values of the regression coefficients in polynomial functions, the statistical testing is performed, i.e. checking the model adequacy at the checkpoints. Based on the value of the Student criterion in the control points, the hypothesis of adequacy of describing the examined problem with the defined mathematical model is accepted or rejected.

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