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THE SOFTWARE APPLICATION FOR MATHEMATICAL MODELLING OF TECHNOLOGICAL PROCESS IN TEXTILE INDUSTRY

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Abstract: *This paper presents a statistical processing program of the experimental data by a program a second degree central composite rotatable in order to obtain a mathematical model and the graphic representation thereof. The paper presents a software application, designed so that it can be used by any individual, without requiring specific knowledge of computer, because every step is accompanied by messages in clear. The application is used by students in the last year of study, by PhD. students and researchers, because it appeals to the deep knowledge of textile technology and mathematical statistics. In the first stage will select, after specific criteria, the values of those technological parameters that influence the outcome of the analyzed process, which are input values for OPTEX application (the acronym of expression OPTIMIZATION OF TEXTILE). Like output values, may be hourly production, yield, etc. The application generates a second degree mathematical relationship, which has in the right part of the equal sign, the technological parameters, denoted by x, accompanied by numerical coefficients and in the left part of the same sign, the result of the analyzed process, denoted by y. The application executes automatically the significance analysis of numerical coefficients and checks the veracity of the mathematical model. It is eliminated from relation, those coefficients whose values are insignificant. The accuracy of new model is show through a clear message and also is displayed the correct form of the mathematical relation. On demand are realized the graphics in 3D and 2D, which to allow finding, according to certain rules, the optimal values of the process and it obtain the calculated value of the output variable. With these technological parameters, in natural values, regulate the real process and it obtained the measured value of the output variable. The measured value obtained is compared with the value calculated and if the difference between these is acceptable, it considered that the analyzed textile process is optimized. If this difference is considered unacceptable, it resumes the OPTEX application with other input values. After completing the entire program data can be saved as independent files or can list printed in alphanumeric reports (text) or graphics. The "Optex" is easy to operate, requires a little time to perform processing of experimental results and has the advantage of being based on the algorithm used to solve a mathematical model manually. The application performed can be a useful tool in empirical studies on optimization of technological processes.*

Key words: *technological parameters, textile process, regression coefficients, software, mathematical modelling.*

1. INTRODUCTION

Textile technological processes depend on a multitude of technological parameters. The management of such process that gives the best results is a laborious operation. Choosing the group of technological parameters which to ensure high yields and obtain proper quality cannot be achieved empirically, based only on personal experience. It requires the use of scientific methods to ensure the selection of technological parameters to achieve the objective. Making research using mathematical methods planning and analysis of experiment eliminates the passive methods of research and increase scientific activities efficiency. Used mathematical methods for planning the experiment provide increased manoeuvre opportunities for researcher, facilitates problem formulation, experimental results have a clear and convincing nature and permit a rapid interpretation of the results generated by the mathematical model. Interpretation of the mathematical model to optimize the process require the experience of researcher, because verification of the veracity model it does by adjusting the actual process parameter values provided by basic theoretical elements.

This paper presents a statistical processing program of the experimental data by a program a second degree central composite rotatable in order to obtain a mathematical model and the graphic representation thereof. [4]

2. GENERAL INFORMATION

Using mathematical methods of planning the experiment provides increased opportunities for maneuver researcher facilitates problem formulation, experimental results gives a clear and compelling character and rapid interpretation of results.

Active method of developing mathematical and statistical models involves obtaining experimental data after performing experiments directed.

To determine the functional relationship runs a number of experiences ordered in a certain way, and all these experiences is an experimental program (equation 1).

$$Y=f(x_1, x_2, \ldots x_k) \quad \textbf{(1)}$$

For each independent variable (technological parameter of the process), in the considered experimental region, it sets a basic level (z0I) and a variation step / day. And it calculates specific values of experimental program. The addition the variation step to base level it obtain the upper level and the diminish of base level with variation step it obtain lower level value of technological parameter. The transition from the natural values of the independent variables in coded values is performed by transforming the variable according to the relation 2.

$$x_i = \frac{z_i - z_{0i}}{\Delta z_i} \quad \textbf{(2)}$$

The coded value Xi of the parameter; Day - the natural value of the parameter;
z_0 - the natural value of the parameter in the central region of experiment
z_i - the natural value of the step of variation for the parameter

With the encoded values of parameters it complement experimental matrix, the number of experiments in the array must exceed the number coefficients of the mathematical model to be determined. For example, the experimental matrix for two variables is the form [1, 2, 3,6].

Table 1: The experimental matrix for the two independent variables

No. Crt.	Independent variables				Dependent variables
	X_1		X_2		Mesured value
	cod	real	cod	real	$Y_{mesured}$
1	-1		-1		
2	+1		-1		
3	-1		+1		
4	+1		+1		
5	-1,414		0		
6	+1,414		0		
7	0		-1,414		
8	0		+1,414		
9	0		0		
10	0		0		
11	0		0		
12	0		0		
13	0		0		

The coefficients of equation 3, is calculated by the method of least squares.

$$y = b_0 + \sum_{1}^{k} b_i x_i + \sum_{\substack{1 \\ i \neq j \\ j=i+1}}^{k} b_{ij} x_i x_j + \sum_{1}^{k} b_{ii} x_i^2 \quad \textbf{(3)}$$

The coefficient values are tabulated according to the literature [1-4].
To verify the significance of the model coefficients b_0, b_i b_{ii}, b_{ij} using Student test [1-4]
The calculating of confidence interval coefficients is done with equation 4.

$$|\Delta b_i| = t_{\alpha;n} s_{bi} \quad \textbf{(4)}$$

Where: $t_{\alpha,n}$ - Student criterion for materiality α and n number degrees of freedom;
S_{bi} - standard deviation of the regression coefficient.

The significance of regression coefficients check if the absolute value of the coefficients *bi* to be greater from confidence interval (equation 5).

$$|b_i| \geq |\Delta b_i| \quad \textbf{(5)}$$

If the above relation is not satisfied, the calculated regression coefficient is insignificant, that coefficient is removed from the model. The next step is the verification of the model adequacy. The objective of this verification is to determine the ability of the model to represent, with the probability chosen, modelled process and if yes, it will be used for process optimization study analyzed. Hypothesis about the adequacy of the model is checked using the test Fischer, whose calculated value is determined by the relation 6.

$$F_C = s^2_{conc} / s^2_0 \quad \textbf{(6)}$$

Where: S^2_{conc} – according dispersion; s^2_0 - central dispersion.

The mathematical model is appropriate when the relation 7 is satisfied:

$$F_C < F_{\alpha, \mu 1, \mu 2} \quad \textbf{(7)}$$

Where: α is level of significance. μ_1, μ_2 - number of freedom degrees of the dispersions.

3. DESCRIPTION THE SOFTWARE APPLICATION

The software application "Optex" is made in Delphi, version 3.0. Basic software required for running the program is Windows. Minimum space allocated to the program is 518KB.

The transition from one stage to another program is done with the mouse; the data are entered in the respective boxes. After completing the entire program data can be saved as independent files or can list printed in alphanumeric reports (text) or graphics.

The program is easy to operate, requires a little time to perform processing of experimental results and has the advantage of being based on the algorithm used to solve a mathematical model manually.

4. USING MANUAL WITH EXEMPLES

The program starts by loading from the CD or by icon's selection. Running the program beginning with opening the window conversational "initial data" (figure 1) which selects the number of independent variables in the X box, and is confirmed by pressing the button "Select X". The "Reset X" isused to reset the initial data, where appropriate. After confirmation of choice of the number of independent variables X, are introduce the names and values of the technological parameters , independent variables (the base value and the variation step), and after the experimental matrix is filled in with experimental values obtained $y_{mes.}$ in each box of the array. Validation of the values $y_{mes.}$ is made by pressing "Enter".

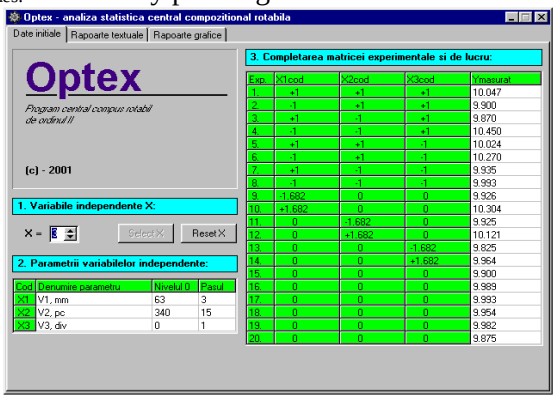

Fig. 1: *The window conversational "initial data"*

Proceed to next step for the calculations of the coefficients of the mathematical model by opening the table "textual reports," which has three options. The option „technological parameters-independent variables" (figure 2) shows the table with coded values and natural values of the independent variables-technological parameters for the five levels of the experimental matrix.

The table "coefficients of the regression, the adequacy of model" (figure 3) shows the general formula for the model for the selected number of independent variables as well as numerical values of the regression coefficients, the verification of their significance and verification of adequacy of the mathematical model.

The table „Experimental and work Matrix" (figure 4) shows the measured and calculated values of the dependent variable Y and the percentage deviations between these.

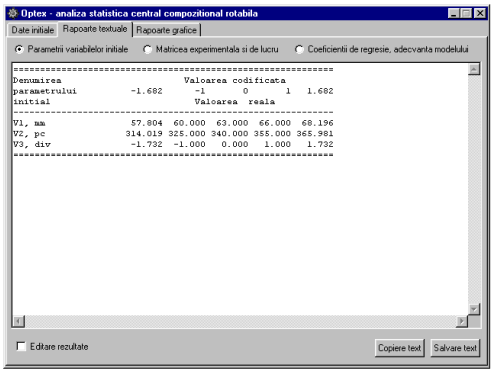

Fig. 2: *The option „technological parameters-independent variables"*

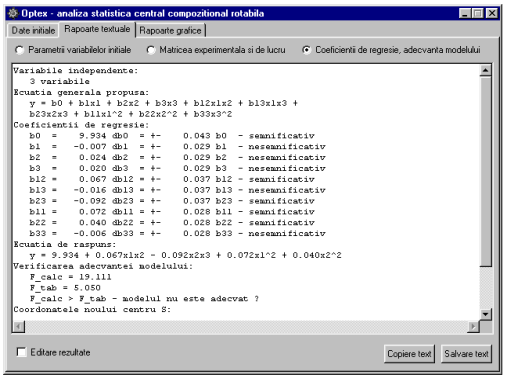

Fig. 3: *The values of regression coefficients, their significance and adequacy of the model*

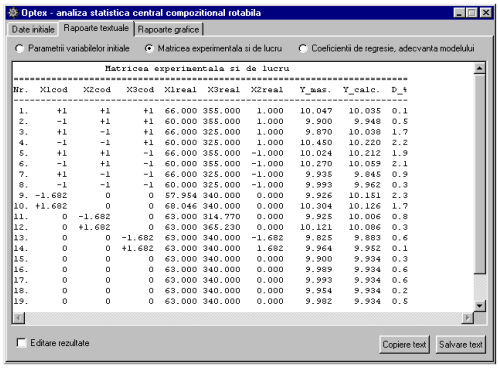

Fig. 4: *Experimental and work matrix*

It offers a choice of an editing mode (box "Edit Results"), copy the text or save the text (button "Copy Text" or "Save text"). Open the window "Graphical reports" has the effect of generating a response surface 2D and 3D graphic (figure 5).

The box from base from Figure 5 "Changing significance of regression coefficients" gives the user the opportunity to decide on changing significance of one or more regression coefficients. Box "Cancelling independent variables" provides the ability to generate response surfaces 3D and 2D for any combination of two independent variables by cancelling other independent variables (the cancellation of coded value is equivalent with an optimal natural value). The buttons "Copy

3D", "Save 3D", "Copy 2D", "Save 2D", have the same effect like from last step and the "Refresh "button allows returns to previous version for changing the significance of regression coefficients.

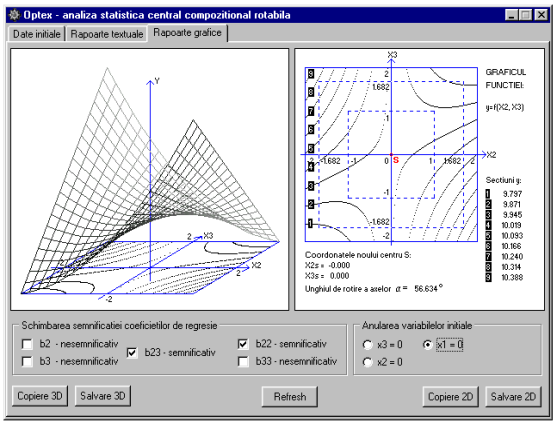

Figure 5: *The graphics 3D and 2D*

5. CONCLUSIONS

This paper presents a software application OPTEX - a statistical processing program of the experimental data by a program a second degree central composite rotatable in order to obtain a mathematical model and the graphic representation thereof. OPTEX program allows mathematical modelling of a technological process, highlighting trough the values and signs of numerical coefficients, the influence of technological parameters as independent variables on the dependent variable. Also, the program OPTEX allows optimization of the technological modelled process, by analyzing regression equation and by analyzing 2D and 3D which it generates upon request [4].

The program allows mathematical modelling of the technological process in any field. The application allows students in knowledge modelling process. Optimal nature of the dependent variable is obtined by comparing the calculated and measured values, obtained after adjusting the values of the new parameters of technological process. [5,6].

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