ANNALS OF THE FACULTY OF ENGINEERING HUNEDOARA
2006, Tome IV, Fascicole 2, (ISSN 1584 – 2665)
FACULTY OF ENGINEERING HUNEDOARA,
5, REVOLUTIEI, 331128, HUNEDOARA

MATHEMATICAL MODELS ADAPTED FOR THE AREA OF THE IRON CAST CYLINDERS

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ABSTRACT:
Often when engineers analyze a system to be controlled or optimized, they use a mathematical model. In analysis, engineers can build a descriptive model of the system as a hypothesis of how the system could work, or try to estimate how an unforeseeable event could affect the system. Similarly, in control of a system, engineers can try out different control approaches in simulations.
The technical conditions, which are imposed to the cast iron cylinders in the exploitation period, are very different and often contradictory. The obtaining of various physical and mechanical properties in the different points of the cylinders meets difficult technological problems in the industrial condition. This supposes us to know many technological factors, which lead to the exploitation of this deformation equipment.
One of the parameters, which are determined the structure of the irons destined for rolls casting, is the chemical composition. If we do not respect this composition, which are guarantied by the exploitation properties of the each roll in the stand of rolling mill, this leads to rejection.
In this area, we propose one of model when describe the mathematical relations between the different variables.

KEYWORDS:
mathematical model, modelling, mechanical properties, chemical composition, graphical interpretation, parameters

1. INTRODUCTION

A mathematical model usually describes a system by a set of variables and a set of equations that establish relationships between the variables. The values of the variables can be practically anything. The variables represent some properties of the system, for example, measured system outputs often in the form of signals, timing data, counters, event occurrence (yes/no). The actual model is the set of functions that describe the relations between the different variables.

Decision variables are sometimes known as independent variables. Exogenous variables are sometimes known as parameters or constants. The variables are not independent of each other as the state variables are dependent on the decision, input, random, and exogenous variables. Furthermore, the output variables are dependent on the state of the system (represented by the state variables).

In mathematics, statistics, and the mathematical sciences, parameters are quantities that define certain characteristics of systems or functions. When evaluating the function over a domain or determining the response of the system over a period of time, the independent variables are modulated, while the parameters are held constant. The function or system may then be reevaluated or reprocessed with different parameters, to give a function or system with different behavior. Loosely speaking, then, parameters are constants in a narrow context but are variables in a larger context.

Objectives and constraints of the system and its users can be represented as functions of the output variables or state variables. The objective functions will depend on the perspective of the model's user. Depending on the context, an objective function is also known as an index of performance, as it is some measure of interest to the user. Although there is no limit to the number of objective functions and constraints a model can have, using or optimizing the model becomes more involved (computationally).

Mathematical models are usually composed by variables, which are abstractions of quantities of interest in the described systems, and operators that act on these variables, which can be algebraic operators, functions, differential operators, etc. If all the operators in a mathematical model present linearity the resulting mathematical model is defined as linear. A model is considered to be nonlinear otherwise. In a mathematical programming model, if the objective functions and constraints are represented entirely by linear equations, then the model is regarded as a linear model. If one or more of the objective functions or constraints are represented with a nonlinear equation, then the model is known as a nonlinear model.

A deterministic model is one in which every set of variable states is uniquely determined by parameters in the model and by sets of previous states of these variables. Therefore, deterministic models perform the same way for a given set of initial conditions. Conversely, in a stochastic model, randomness is present, and variable states are not described by unique values, but rather by probability distributions.

Usually it is preferable to use as much a priori information as possible to make the model more accurate. Therefore the models are usually considered easier, because if you have used the information correctly, then the model will behave correctly. Often the a priori information comes in forms of knowing the type of functions relating different variables. These parameters have to be estimated through some means before one can use the model.

2. THE MODELLING

Another basic issue is the complexity of a model. In the modelling of the metallurgical procesess, especially the casting complex procesess, is necesary to analyse each phases of the processes, and each mechanical part of the cast pieces into the model. However, the computational cost of adding such a huge amount of detail would effectively inhibit the usage of such a model. Additionally, the uncertainty would increase due to an overly complex system, because each separate part induces some amount of variance into the model. It is therefore usually appropriate to make some approximations to reduce the model to a sensible size. Engineers often can accept some approximations in order to get a more robust and simple model.

Any model contains some parameters that can be used to fit the model to the system it shall describe. In more conventional modelling through explicitly given mathematical functions, parameters are determined by curve fitting. An important part of the modelling process is the evaluation of an acquired model. Usually the engineer has a set of measurements from the system which are used in creating the model. Then, if the model was built well, the model will adequately show the relations between system variables for the measurements at hand.

A common approach is to split the measured data into two parts. Training data and verification data. The training data are used to train the model, that is, to estimate the model parameters. The verification data are used to evaluate model performance. Assuming that the training data and verification data are not the same, we can assume that if the model describes the verification data well, then the model describes the real system well.

Engineering is the application of scientific and mathematical principles to develop economical solutions to technical problems, creating products, facilities, and structures that are useful to people. Engineers use imagination, judgment, and reasoning to apply science, technology, mathematics, and practical experience. The result is the design, production, and operation of useful objects or processes.

As with all modern scientific and technological endeavours, computers and software play an increasingly important role. Numerical methods and simulations can help predict design performance more accurately than previous approximations.

One of the parameters, which are determined the structure of the irons destined for rolls casting, is the chemical composition. If we do not respect this composition, which are guarantied by the exploitation properties of the each roll in the stand of rolling mill, this leads to rejection. All FNS type rolls are alloyed especially with chrome, nickel and molybdenum, in different percentages. The irons destined to these cast rolls belong to the class of low-alloyed irons, with reduced content of these elements. The technological instructions firmly state the elements required to raise the quality of rolls.

The statistical methods of the analysis do not solve a whole series of appearances regarding to the decisions model to establish the management of the process. For this reason, in parallel with the statistical methods, was developed the methods of optimization.

As part as the basic experiment, through the regression analysis, it was aimed the determination of the mathematical functions form, which connect the dependent variables u of the technological process with the free variables (the technological parameters) x, y, z,..., meaning u = f(x, y, z,...), on the strength of some experimental determinations, this after it accomplished a dispersion analysis of these correlation data. The determination of what real coefficients enter into the expression u = f (x, y, z,...) is done, in the vast majority of the cases, through the method of the smallest squares.

Depending on the number of free variables (the technological parameters) that we consider, it was chosen the analysis of multiple regressions studying the influence of free variables x, y, z,... upon the dependent variable u. In this sense, it was aimed to establish calculus methodologies of values for the technological parameters in the manufacturing process of the semihard rolling mill cylinders, obtained through the simplex classical cast of the iron with nodular graphite, for which the mechanical features of rolling mill cylinders have the required values.

Having "*n*" experimental points, respectively $(x_1, y_1, u_1)_1$, $(x_1, y_1, u_1)_2$, ... $(x_1, y_1, u_1)_n$, we need to determine the real coefficients c_0, c_1 and c_2 in the equation of the plan. This is accomplished through the method of the smallest squares. We consider the variations limits of the variables (x, y, z), as well as the variation limits of the analyzed features. Also, in the limits of graphical representation (lim x_{inf}, lim x_{sup}, lim y_{inf}, lim y_{sup}, lim z_{inf}, lim z_{sup}), as well as the average values of the variables and of the analyzed features (x_{med}, y_{med}, z_{med}, u_{med}) are stated.

The values processed were made using Matlab calculation program. Using this calculation program we determine some mathematical correlation, correlation coefficient and the deviation from the regression surface. This surface in the four-dimensional space (described by the equation) admits a saddle point to which the corresponding value of hardness is an optimal value of alloying elements.

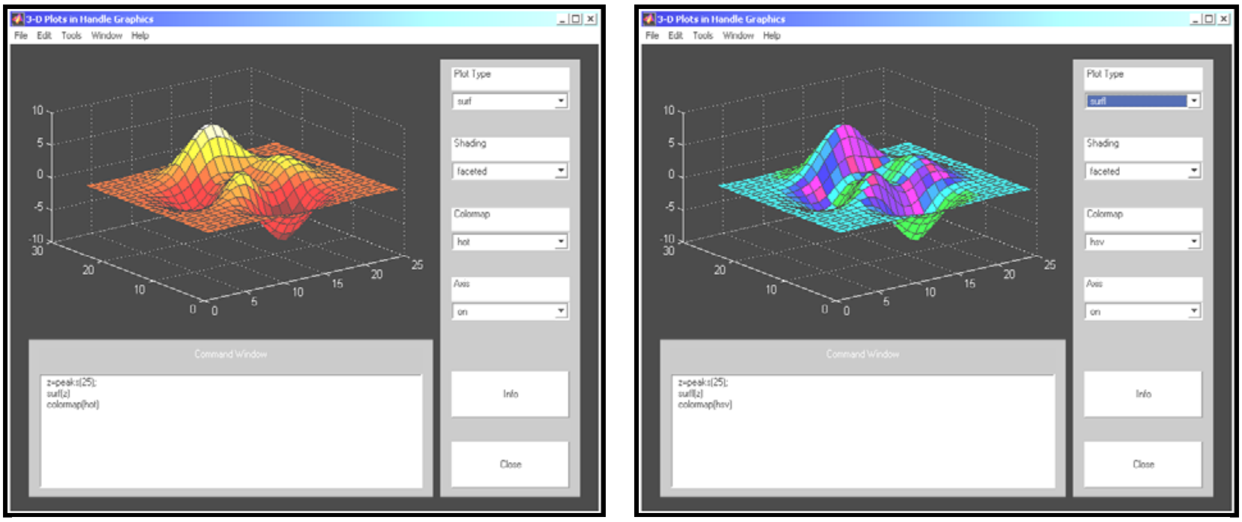

Figure 1.The surface in the four-dimensional space
(described by the mathematical equations)

The existence of a saddle point inside the technological domain has a particular importance as it ensures stability to the process in the vicinity of this point, stability which can be either preferable of avoidable.

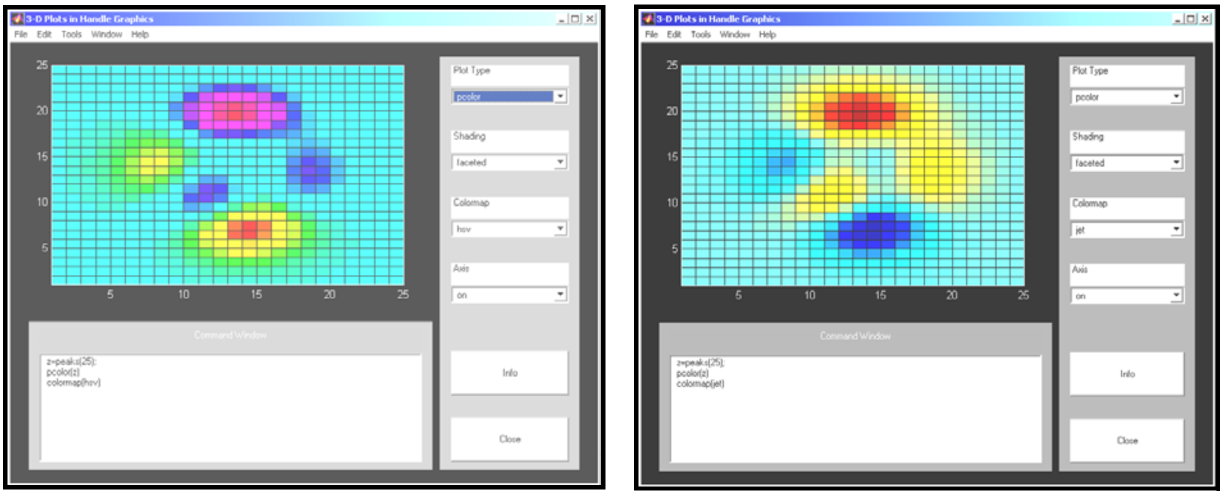

Figure 2. The variation domains (described by the equation,
through the projection of the hiper-surface)

The behavior of this hyper-surface in the vicinity of the stationary point (when this point belongs to the technological domain) or in the vicinity of the point where the three independent variables have their respective average value, or in a point where the dependent function reaches its extreme value in the technological domain (but not being a saddle point) can be rendered only as a table, namely, assigning values to the independent variables on spheres which are concentric to the point under study. Knowing these level curves allows the correlation of the values of the two independent variables so that we can obtain a viscosity within the required limits.

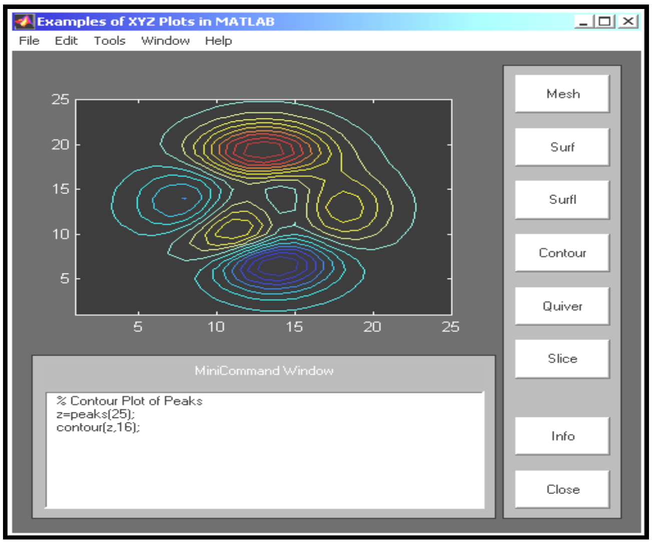

Figure 3. The level curves (described by the equation, through the projection of the hiper-surface)

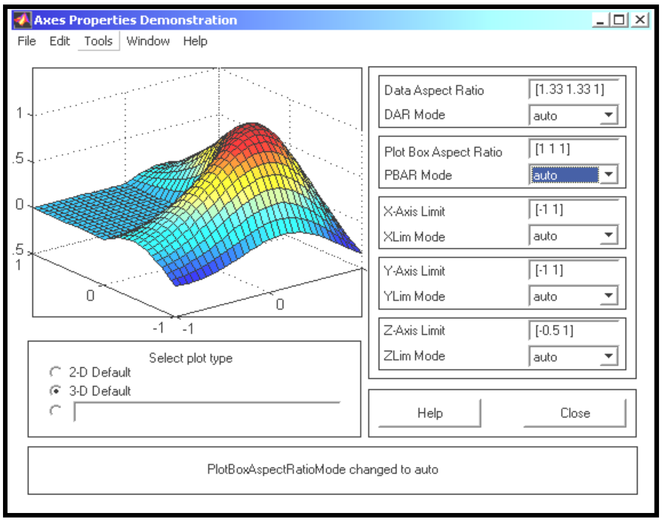

Figure 4. Screen for the regression surface volume variation generation for the average values

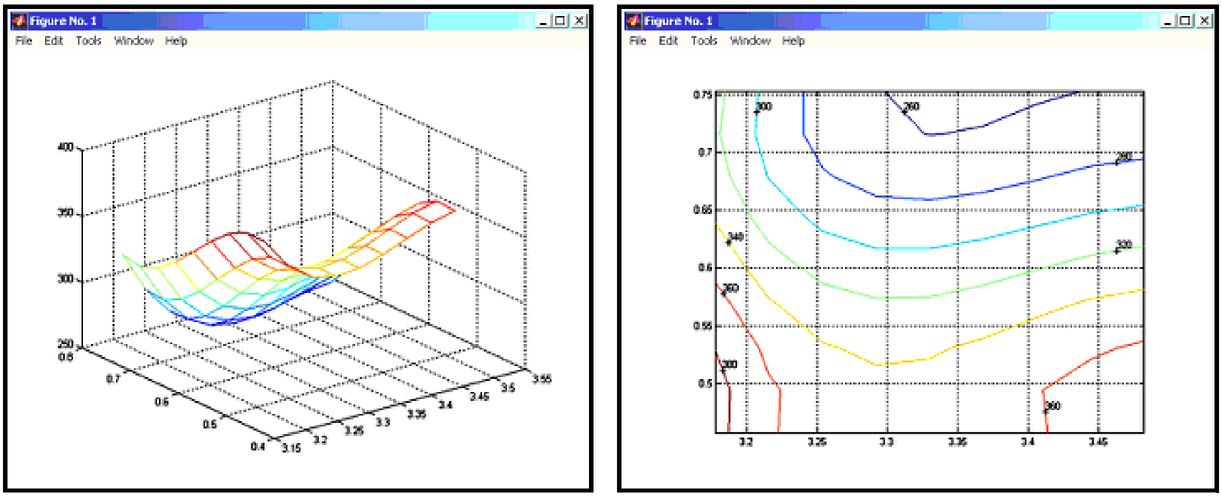

Figure 5. Some examples for the surface representation and the variation domain determined by the level curves

Figure 4 presents the screen, which generates the correlation surfaces, meaning the projection in the two-dimensional plan of the variation volumes of the regression surfaces. These diagrams are built for the average values of the parameters (x_{med},

y_{med}, z_{med}), only that through the representation of the diagrams for parameters values contained in the variations limits we can obtain adjusting diagrams, with which we can completely controlled the process. In Figure 5 some examples for the surface representation and the variation domain determined by the level curves are presented.

3. CONCLUSIONS

Engineering is concerned with the design of a solution to a practical problem. A scientist may ask why a problem arises, and proceed to research the answer to the question or actually solve the problem in his first try, perhaps creating a mathematical model of his observations. By contrast, engineers want to know how to solve a problem, and how to implement that solution.

In other words, scientists attempt to explain phenomena, whereas engineers use any available knowledge, including that produced by science, to construct solutions to problems.

The values processed were made using Matlab calculation program. Using this calculation program we determine some mathematical correlation, correlation coefficient and the deviation from the regression surface. This surface in the four-dimensional space (described by the equation) admits a saddle point to which the corresponding value of hardness is an optimal value of alloying elements.

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