APPLICATION OF CAD DESIGN OF TECHNOLOGICAL PROCESSES IN THE FIELD OF MATERIAL SCIENCE

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Abstract. *A review of the existing methods applied to multi-criteria decision aiding has been made as well as the multi-criteria approach to a class of problems in the field of material science has been defined. The multi-criteria decision aiding has been successfully applied to determine appropriate compromise decisions about the examined parameters of a number of technological processes of welding, chemical thermal processing, iron covering, etc. The approach presented determines the values of technological factors satisfying the requirements of users simultaneously to a number of values examined and proposes a solution for the relatively highest thresholds at one and the same time*

KEY WORDS. *SIMULATION, ANN, MODELING, OPTIMIZATION TECHNOLOGICAL PROCESES.*

1. INTRODUCTION

The modern problems of examining the parameters of new and conventional materials and technological processes are multi-criterial and conflict in principle. This nature of the problems is grounded by the fact that, with there examination, it is necessary to provide a certain set of parameters that have to satisfy users' requirements. The solution sought usually consists in determining those combinations of controlling parameters that provide the set of quality parameters specified. The choice of the assessment system of criteria and their rating according to the degree of significance is a problem difficult to formalize. It does not have unambiguous interpretation inevitably causes subjective decisions.

The problem of multi-criteria decision aiding could be most generally defined as a process with:

- a great number of parameters of the solution with a complex interaction among themselves;
- complex cause-and-consequence relations of the solution parameters and the attributes or aims;
- a set of alternatives, which could be reduced to a limited number and in this case the form of cause-and-consequence has to be used.

Due to that reason, looking for an appropriate model to solve a certain multi-criteria problem, one should define first the type of the situation, which is most suitable for solving the problem. An important element of the information base is the component implementing the method of planning the experiment. The main instrument and means of the modern scientific technologies is modeling as by it one can formulate the multi-criteria problem. The models of the complex objects and phenomena are often integrated including contents-describing and formal mathematical parts.

Hence, the study mainly emphasizes on different indices of quality providing including the following groups of criteria: strength (with static and dynamic loading), stiffness (E-module) and toughness (of the material/article), wear-out resistance and hardness, high temperature resistance, appropriate primary cost, compatibility with environment and the possibility of recycling.

2. ANALYSIS OF EXISTING METHODS

An approach to solving the problem (1) is to find the complete set of effective points on the basis of which the decision maker /DM/ chooses one solution. Such algorithms of linear continuous multi-criteria problems have been developed [1], [2]. They have a complex structure and operate slowly. On the other hand, the number of the effective points could be very big and thus make difficult the choice of a decision by the DM.

Another possible approach is to interact directly with the user and his/her preferences to obtain different compromise decisions. In that case, the DM should have a possibility to assess and compare the different solutions obtained. Independently of the method used to find out an effective point, this point has to reflect the DM's preferences to a certain extent. That is why in the multi-criteria decision aiding (MCDA) generally there are two stages: the stage of a dialog with the DM and the stage of computing the effective point. They are interactive procedures [3], which comprise great part of the well-known methods of solving a MCDA problem.

The criteria thus formulated are directly connected with high serviceability (functionality) and quality (constructional and operational properties) as well as economic efficiency.

The optimal matching of all these trends defines the efficiency of materials, i.e. their capability to meet the challenges of engineering in the best way on each stage of its development. Thus a set of problems of multi-criteria compromise decision-making could be formulated also by multi-criteria compromise optimization of one and the same class for which to is necessary to build an appropriate modern instrument in the process of study.

According to the information available about the DM's preferences, the methods of solving MCDA problems can be divided into three main groups:

1. when the DM is able to give a complete information about his/her preference;
2. when there is not such information available;
3. when this information is given by the DM in the process of solving the problem.

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With the problems in the field of material science, the DM does not have information about his/her preference and for that reason the methods developed within the first group cannot be used.

The second group of methods is characterized by generating the whole set of effective solutions. The set of effective solutions is presented partially or entirely by the DM. Such methods are: the method of weight coefficients or *P* problem [4],[5],[6], the method of limitations [7],[8]; the method of weighed Chebishev's standard [9]. These methods are able to generate the whole set of effective solutions of the MCDA. However, their disadvantage lies in the big calculation resources necessary for generating and the impossibility or difficulty of the DM to choose a solution from that set. However, they serve as a base of the interactive methods.

The third group of methods does not require knowledge on the function of preference by the DM. They are the base of the interactive man-computer procedures. The DM interacts with the computer (the algorithm set) on the purpose of clearing and giving additional information about the way of reaching a compromise decision.

The methods consist of three basic steps:

1. Giving the DM's requirements;
2. Finding a compromise solution;
3. Checking if the solution found satisfies the DM.

These methods have been developed most intensively for the past few year and are the base of further studies on the problem of MCDA.

The method of limiting planes [10] is very useful for the peculiarities of the problems in the field of material science. This method can be examined as a variation of the method of the admissible destinations. The methods of this class are unique with the approach, which they use to find the best compromise decision. They reduce the area of criteria iteration reflecting the planes and thus eliminating the stage of looking for a destination. Here precise information about trade-off coefficients is required.

3. APPROACH TO SOLVING MULTI-CRITERIA PROBLEMS IN THE FIELD OF MATERIAL SCIENCE.

The multi-criteria approach [10] proposed is characterized with the peculiarity of defining only one effective point of the whole set, which, according to its nature, turns to be fully sufficient for the different processes examined. That solution is characterized with the peculiarity of the problem class being solved and the solutions are with the highest thresholds of the quality indices examined. Their determination is usually assisted by the nature of the multi-criteria problem defined by the regression models of particular parameters of quality. In the field of material science, the latter require relatively one and the same preferences to all criteria as a whole. The solution presented meets the requirements mentioned and corresponds to the maximal effective point. It is determined after the discretization of the variables with certain exactness and building a transformation containing the lowest value of the criteria examined.

Applying this computation technology, technological solutions important for a number of technologies have been obtained and proved in practice [11]-[14].

The approach has been developed in the form of suitable software [10] that automates the calculations and determines the solutions necessary in a extremely easy way.

Before being visualized, the criteria have been put on a normally distributed scale by finding the discrete extremes and excluding the areas where the function has infinite or indefinite values. The movable limits move along this scale filtrating the visualized multi-dimensional spaces and giving a possibility to focus exactly on the decisions, which the researcher is interested in. The multiple criteria approach is used to visualize the numerical transformation of criteria and this visualization is called a filter. Experiments have been made with geometric mean, arithmetic mean, max and min filters and all decisions found out by these filters are non-dominated. The approach visualizes the symbolic data, transforming it into geometric information that helps to form a real picture of the data. The movable limits are a tool, which is used to focus on some details of the picture, thus finding the decisions looked for. The approach helps the decision-maker to get access to the limits as much as possible from the point of view of criteria. This information aids the participation of the decision-maker's intuition towards the problem and helps him/her to identify and fulfill the aim intentionally

In previous studies, team members conducted research that is summarized in Fig. 1 - Fig.4.

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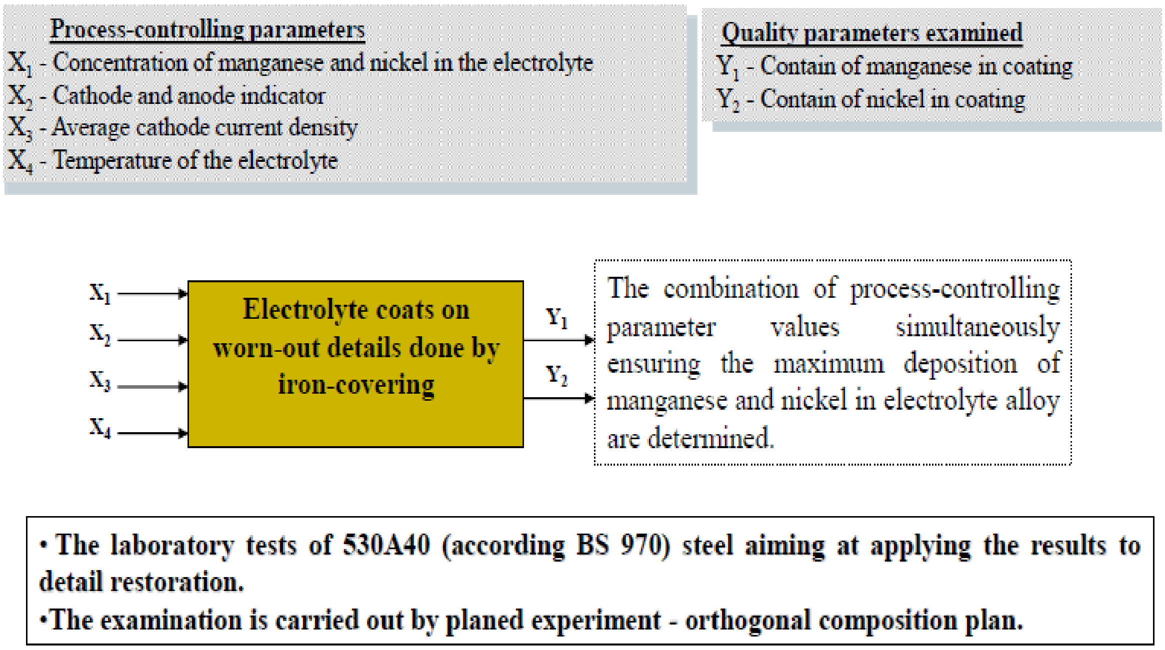

Fig 1. *Electrolyte coats on worn-out details done by iron-covering [12]*

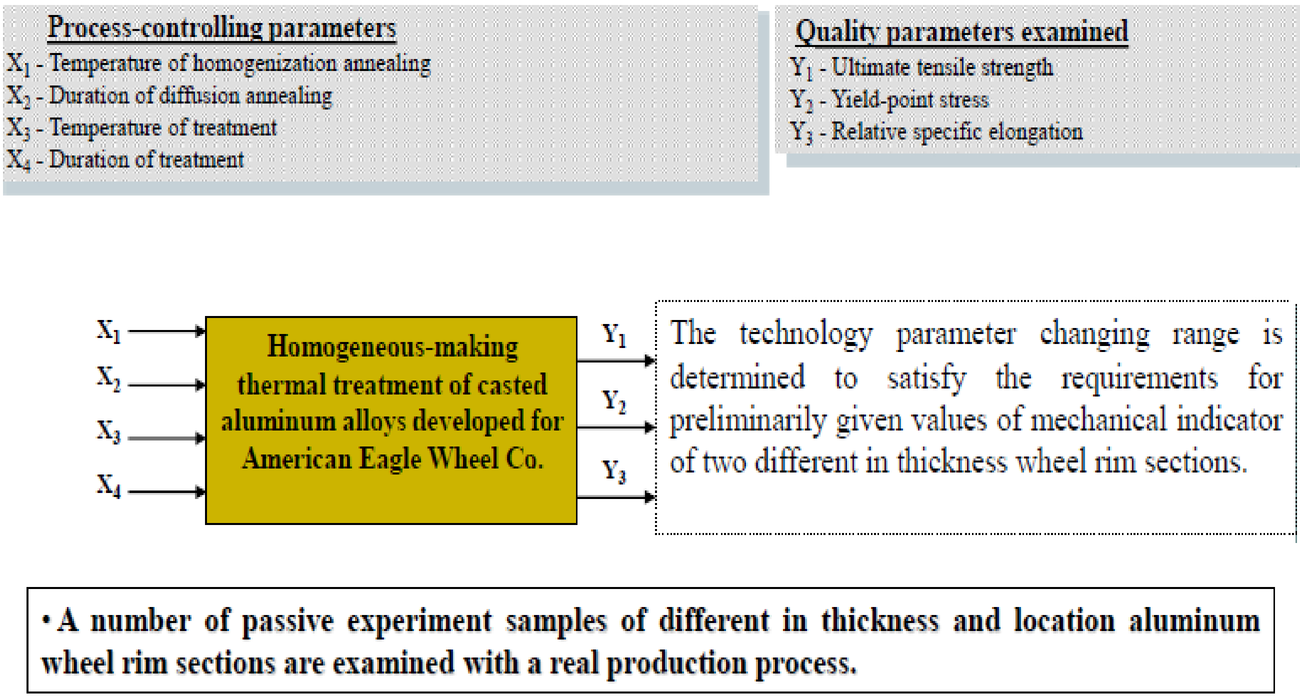

Fig. 2. *Homogeneous-making thermal treatment of casted aluminum alloys developed for American Eagle Wheel Co. /Ordered Company Survey/*

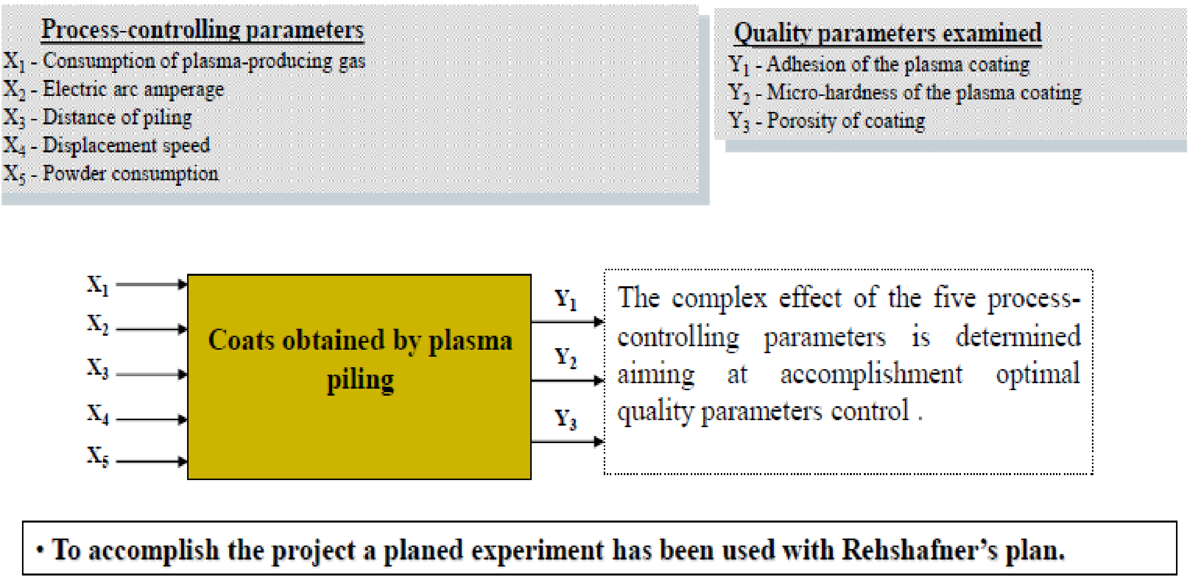

Fig 3. *Coats obtained by plasma pilling [14]*

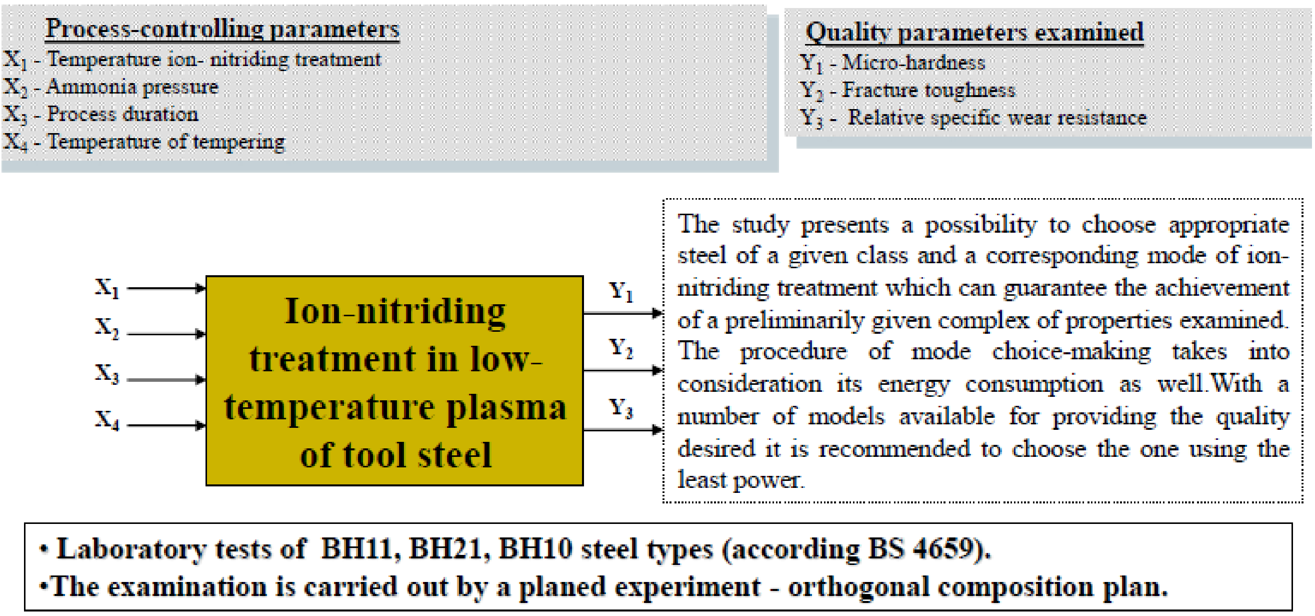

Fig 4. *Ion-nitriding treatmentin low-temperature plasma of tool steel [11, 13]*