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POSSIBLE INFERENCE ENGINE PART FOR AN EXPERT SYSTEM IN MATERIALS SELECTION

In the material choice, experience plays a big role and for the young engineers an instrument for evaluating and diagnosis of the materials choice might be valuable. This paper introduces an original method of evaluation of the materials choice that can be used as a possible part of an inference engine for an expert system in materials selection.

***Key words**: materials selection, method of evaluation, expert system, inference engine.*

1. Introduction

Some times, in the metallic materials selection it occurs the situation in which, two or three possible variants of materials are not to easy to rank according to the choosing criteria established and then, the experience of the engineer is the one which decides.

For an experienced person in the materials engineering field, there is always a trend in using the materials one knows better and disregards other possibilities of choice, excluding the new materials and loosing, in this manner, from many points of view, both economically and technically [1].

This is why efforts are being made to introduce in the practical use the expert systems in materials selection, if not yet for the selection itself, but for the evaluation of a selection previously made.

The architecture of a classic expert system in materials choice comprises the user interface, the base of knowledge, the inference engine, the data and the explicative module [2].

The role of each of them is not difficult to mention: the user interface provides the means of introducing the questions addressed to the expert system and also ensures the access to the answers - results.

The base of knowledge comprises the rules one can use to select the requested answers from the data base, in other words to obtain a report. It is the correspondent of the program in a conventional software application.

The inference engine is the part that executes „the thinking" according to the content of the knowledge base. The inference engine seams to be an interpreter, base program executing the instruction in the sequence established by the main program but has one important characteristic namely, it establishes alone the order of execution of instructions as a function of the processing situation.

The explicative module can describe, when the user requests, the reasoning line of an answer, and it is a part of the user interface.

The data for an expert system are mainly facts referring to the situation analysed. The facts are logical affirmative propositions describing a given situation. In some descriptions of the architecture of the expert system data are being described as base of facts. The expert system uses also data as in the common sense of the word and it can interrogate a compatible data base [2].

2. Method of evaluation and diagnosis of the metallic materials choice

Because the way of judgement in the choice of a variant or an another often remains "hidden", and in this way, hard to discuss into the technical councils, a method to enhance transparency in this domain would be very valuable[1].

Moreover, in the situation in which, it is the case to discuss the correct or incorrect choice of a material for a given purpose, in impartial judgement tool would be desirable. In the following the principles of such a method will be shortly presented.

The idea of conceiving this calculation method started from the matrix of rapid evaluation of the environment impact method, used in the environment impact assessment field [3, 4, 5, 6, 7].

The method [3,1] is based on a standard definition of the important criteria of evaluation as well as of the ways through which quasi quantitative values can be deducted for each of these criteria.

The variants of choosing a material are being evaluated by rapport to the criteria and one determines for each component a mark, using the defined criteria, ensuring in this manner a measure of the performance for the properties discussed.

The important criteria of choice can be grouped in two categories:

A. Criteria that can change individually the obtained score;

B. Criteria that can not change individually the obtained score.

The values associated for each of the groups of criteria can be determined by using a simple formula. The formula enables the determination of marks for individual components on an equal well defined basis.

The ranking system is constituted as follows:

- the marks for the group A are obtained by multiplying of the values for each criteria

$$(a1)x(a2)=aT \tag{1}$$

(a1), …(ai) – are the marks given for the individual criteria for the group A.

Using the multiplication for the A criteria is important because it ensures the expressing of the weight of each mark, but the simple adding would expressed identical results for different conditions.

- the marks for the group B of criteria are being added, giving a single sum

$$(b1)+(b2)+(b3) = bT \tag{2}$$

(b1),….(bi) – are the marks given for the individual criteria for the group B.

This gives the certainty that the individual marks can not influence the general score but as well as the sum importance of the values from the group B is also in view as a hole.

The sum of marks from the group B is then multiplied with the value resulted form the group A ensuring in this way a final evaluation score (ES).

$$(aT)x(bT)=ES$$

aT is the result of multiplying of all marks A;

bT is the result of the sum of all marks from the B group;

ES is the average score for the analyzed property.

In table 1 we show an example for the reasoning for each property. The table gives some judgement criteria and ranking levels.

Table 1

Example of criteria and ranking levels

Criterion	Scale	Description
A1 The importance of the property for the functioning	4 3 2 1 0	Indispensable for the functioning Very important for the functioning Important for the functioning Little importance for the functioning Not influencing the functioning
Criterion	Scale	Description
A2 Processing possibilities of the material during the technological route	+2 +1 +0 -1 -2	High technological properties for all the needed procedures High technological properties for the most part of the needed procedures and average for the others Medium technological properties for the needed procedures Low technological properties for some of the needed procedures Impossible to be processed efficiently at least in one needed procedure

B1 Disponibility and aquisition price	3 2 1	Most common material Easy to be procured Difficult procuration
B2 Fiability	1 2 3	Lowest Average High
B3 Environment effect, recuperation costs	1 2 3	High Average Low

3. The definition of the components of the evaluation discussion

To define the components of the evaluation discussion means to select the properties that might influence the producing, operation, maintaining and material recovery in the best economical conditions.

The components can be included in classes, like for example:

- properties of the metallic material (PMM) (physical, chemical, mechanical, technological, operational);
- economical and operational properties (EOP);
- ecological properties (Ec P).

For evaluating each variant of material one must build a matrix comprising cells showing the criteria by report of each component. In each cell the mark is being written for each individual criterion. With the given formulas one calculates the ES score. Then the scores are being compared following the table of categories shown bellow.

After being classified into a category the scores can be represented on a graphic or in a numerical presentation. An example is given in table 2.

Table 2

Example for scores conversion in choice motivation

Average score	Category	Category description
+48 at +72	+ D	Best choice
+24 at +47	+ C	Excellent choice
+13 at +23	+ B	Very good choice
+ 7 at +12	+ A	Good choice
0	N	Functions without problems
- 12 at – 7	- A	Not recommended
-23 at –13	- B	Bad choice
- 47 at – 24	- C	Very bad choice
- 48 at –72	- D	Worst choice

An evaluation matrix looks like in the example below but the construction of it remains at the appreciation of the user.

Table 3

Example of matrix of evaluation of the metallic materials choice for a given domain

Component	ES	Category	A1	A2	B1	B2	B3
Material 1 PMM							
Tensile strength							
Elongation							
Young module value							
Welding properties							
Machining							
……………							
EOP							
Acquisition price/kg							

Disponibility							
……………………..							
EP							
Toxicity							
Polluting potential							
…………………….							

The steps that must be followed in the applying of the method are:

- the establishment of the criteria and steps of evaluation;

-the definition of the components and grouping them on classes;

- ranking and computing the evaluation scores;

- conversion of scores in categories;

- the establishing of the category for each class of component;

- graphical representation: score on each class for each variant and category.

The building of the matrix is one of the most important steps in this method because choosing the components can be rather difficult. After it, the evaluation with marks and the calculation are not difficult to perform.

This method ensures the same treatment for each variant of material and because the most of the components (properties) can be measured, ranking them is very easy and the subjectivity, even if it exists is highly diminished.

Nevertheless, the most important advantage of the method is the transparency of the marks, so, of the judgement of each component, or of each criteria of evaluation.

The method is efficient because is more easy to compare numbers obtained in an objective manner than to evaluate opinions or recommendations.

In this initial phase, the preliminary tests made with this method gave results in good agreement with those obtained in the classical manner, but the method is still subject to further improvement.

4. The construction of the inference engine part

Based on the method presented above, to produce the inference engine means to be particular when constructing the three tables that are the matrix of evaluation, to establish the internal algorithm and the calling procedure from the main program..

To be more specific, the inference engine will comprise sets of matrixes made for the selection of materials for the domains of interest for the expert.

For example, in the domain of car building or transport vehicles building one can conceive the three matrixes for the materials selection for the chassis, or for the wheels or for all the other main components.

In a general situation the inference engine can be taught to acquire new sets of matrixes for all the domains of machine building: machine parts, tools, and so on, or for applications in various other industries.

The coupling of these sets of matrixes with the materials data base containing the values of all known, or measured, properties of materials should not be a problem.

It can be solved using external procedures like the subroutines.

The functioning of the expert system based on the inference engine proposed will be like this:

– the operator establishes the need of material choice let say, for a gear wheel and type on the user interface this request;
– the inference engine prepares the set of matrixes made for this kind of selection and offers a specific interface for introducing the requested data, mainly the general technical conditions;
– the operator introduces the technical conditions specific for the given machine part let say: diameter, and other specific sizes, module, number of gear tooth, the hardness after the final heat treatment, the roughness and so on;

- the inference engine through its algorithm asks the data base according the properties necessary to be met by the material to fulfil the request of the user. (It is possible to introduce here a subroutine of calculus for translating in terms of materials properties the technical conditions – for this example – the materials contact fatigue value and the bending fatigue value can be obtained from the general calculus of the gear.);
- the answer from the data base given after the selection made with the three sets of matrixes will be a list ranking the materials in the decreasing order of fitness to the requests made by the user. The program can display only the first ten possible choices or less, but this is a matter of simple algorithmic design.

In the end the user of the expert system can ask, if he considers necessary, an explication of the choice achievement and the inference engine will produce the matrixes with the materials chosen and the reasoning method.

5. Conclusions

We have proven that the method of materials choice [3,1] can stand as a real option for the construction of an inference engine of an expert system in the materials selection.

Adding a neural network based of genetic algorithms for teaching this inference engine to make its own sets of matrixes should be the following step in the achieving of a really performing expert system in the materials selection [8].

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