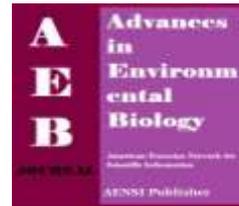




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## Expert System used on Materials Processing

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### ARTICLE INFO

**Article history:**

Received 11 September 2013

Received in revised form 21

November 2013

Accepted 25 November 2013

Available online 3 December 2013

**Key words:**

expert systems, materials processing, design, structure.

### ABSTRACT

The economic agents now realize knowledge as an active relevant for the market organization differentiation. This scenario explains the need for systems that assist the user in the acquisition process and knowledge management. Intelligent systems, known as expert systems serve to this purpose in the extent that they have signed as facilitators in this process. These are systems that are based on expert knowledge, on any subject, in order to emulate human expertise in the specific field. To obtain this knowledge, the knowledge engineers, also called software engineers, need to develop methodologies for intelligent systems. In this area there is still no unified methodology that provides effective methods, notations and tools to aid in development. The use of the recommendations helps the designer to interface with more knowledge giving the possibility to access them in an automated fashion and with various features, resulting in better recommendations and with best models specified by users.

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To Cite This Article: Petrica Vizureanu., Expert System used on Materials Processing, *Adv. Environ. Biol.*, 7(12), 3700-3707, 2013

## INTRODUCTION

In the area of control engineering, it is necessary to work in a continued form in obtaining new methods of regulation to remedy the problem that already exists or to find better alternatives to which they were used previously.

In developing of nonlinear expert system simulation models, the proper selection of input variables is a challenging problem. Therefore, a false combination of input variables could prevent the simulation model from achieving the optimal solution. The presented methodology in this book is an applicable approach for input variable selection in multi-input simulators of expert systems.

Conventional computing programs characterize through an *algorithm* approach as the specialists called it. This approach allows solving a problem by using a preset computing scheme which applies to some structures well-known for input information and produces a result that keep to program operations sequence made within computing scheme. Yet, there is another category of problems whose solving has nothing to do with classic algorithms but supposes a higher volume of specialty knowledge for very strait domains. Such specialty knowledge does not represent the usual "luggage" of a certain human subject, they being on view only for *experts* within the interest domain of the problem. Such problems can treat subjects as automat diagnosis, monitoring, planning, design or technical scientific analysis. Computing programs that solves such problems are known as *expert systems* (ES) and the first development attempts of such programs dates from mid of 1960 – 1970's. Unlike conventional programs, ES are conceived to use, mainly, symbolic sentence, developed through interference. As a branch of *artificial intelligence* (AI), expert systems developed pursuing the study of knowledge processing.

An *expert system* is a program that uses knowledge and interference procedures for solving quite difficult problems, which normally needs the intervention of a human expert to find the solution. Shortly, expert systems are programs that store specialty knowledge inserted by experts.

### Characteristics of ES:

These systems are often used under situations without a clear algorithmic solution. Their main characteristic is the presence of a knowledge base along with a search algorithm proper to the reasoning type.

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An expert system must have compulsory three main modules that form the so-called *essential system*:

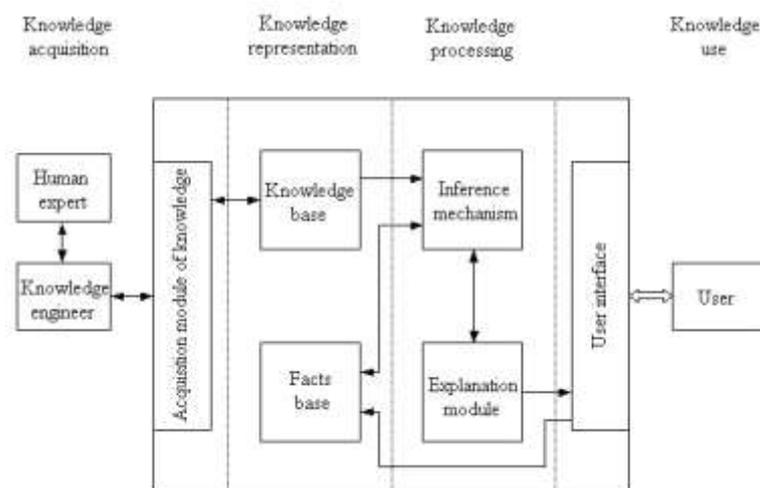
- Knowledge base formed by the assembly of specialized knowledge introduced by human expert. The knowledge stored here is mainly objective descriptions and the relations between them; knowledge base takes part from the cognitive system, knowledge being memorized into a specially organized space; storage form must assure the search of knowledge pieces specified directly through identifying symbols or indirect through associated properties or interferences that start from other knowledge pieces.

- Inference engine represents the novelty of expert system and takes over from knowledge base the fact used for building reasoning. Inference engine pursues a series of major objectives such as control strategy election based on current problem, elaboration of the plan that solves the problem after necessities, switching from a control strategy to another one, execution of the actions preset in solving plan. Although interference mechanism is built from a procedures assembly in the usual meaning of the term, the way in which knowledge are used is not estimated by program but depends on the knowledge it has at command.

- Facts base represents an auxiliary memory that contains all users' data (initial facts that describe the source of the solving problems) and the intermediary results made during reasoning. The content of the facts base is stored generally in volatile memory (RAM) but to user request; it can be stored on hard disk.

*The modules of an ES:*

Communication module assures specific interfaces for users and for knowledge acquisition. User interface allows the dialogue between user and quasi natural language system. It transmits to interference mechanism user's requests and his results. It facilitates equally the acquisition of the initial problem and result communication.



**Fig. 1:** ES modules

Acquisition module of knowledge takes specialized knowledge given by human expert through the engineer, into a not specific form to intern representation. A series of knowledge can arise as files specific to databases or to other external programs. This module receives the knowledge, verifies their validity and finally generates a coherent knowledge base.

Explaining module allows path tracing followed in reasoning process by resolvent system and explanation issuance for the achieved solution by emphasizing the causes of eventual mistakes or the reason of a failure. It helps the expert to verify the consistency of the knowledge base.

*Explanation and updating:*

In terms of the application that it is built for, the effective structure of an expert system can differ towards the standard structure.

For example, initial data can be acquired from the user and from automatic control equipment

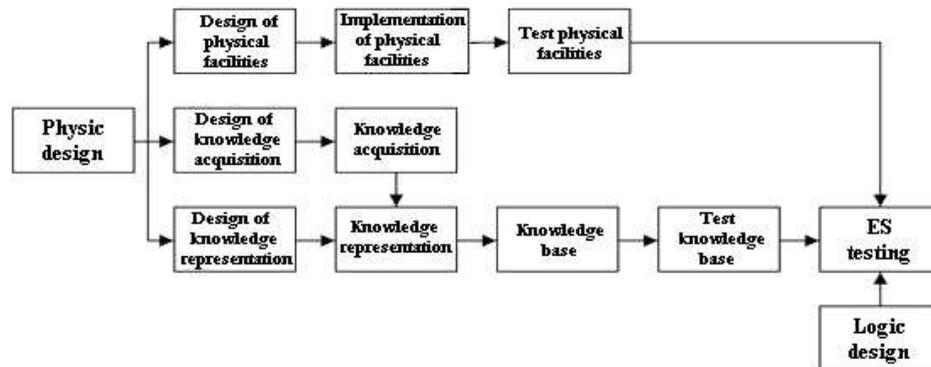
Nevertheless, it is important for expert systems to have two characteristics:

- To explain the reasoning and if it is not possible, human users could not accept it. For this, it must be enough meta-knowledge for explanations and the program must go in intelligible steps.

- To attain new knowledge and to modify the old ones, and usually the only way of introducing knowledge into an expert system is by human expert interaction.

### Development of an ES:

The development of an expert system represents design process of the system going from users' demands of implementing testing and finally launching the product onto market for the effective use. Many times, there are distinctions in design stage between physical design and logical one because these stages need different activities and resources both technological nature and human one.



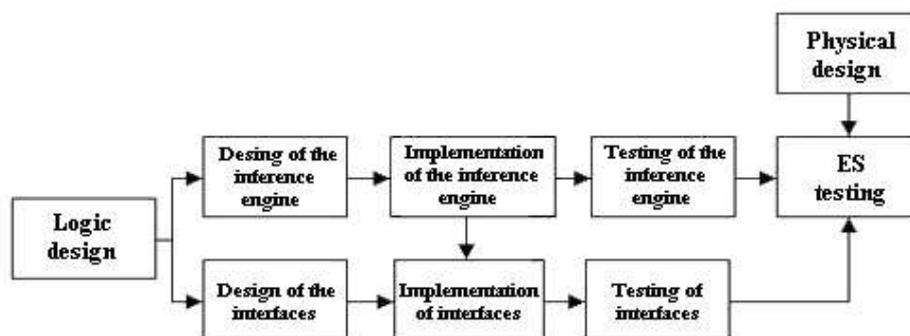
**Fig. 2:** Physical design.

Physical design (figure 2) includes the design of hardware resources and knowledge base, which includes acquisition components of the knowledge and representation way. When physical part is design sub-systems are appropriate implemented and tested. Only afterwards, they can be tested together with logical part.

Logic design (figure 3) refers to software design and realizes parallel to physical one. First, assembly decisions take such as those linked to the election of a programming language or a shell or a toolkit. Both integration problems of the system and security ones must solve. Then inference engine and interfaces are designed. To program inference engine declarative languages are chosen several times. The design of this part of the system can be seen as an activity of software development, as programming engineering says. The particularity of ES is the importance and development of the knowledge base.

In addition, the exclusive accent is not put on developing inference engine program but on developing the other component such as interfaces.

Each subsystem could need different resources (other programming languages or even other hardware resources) and distinct development techniques.



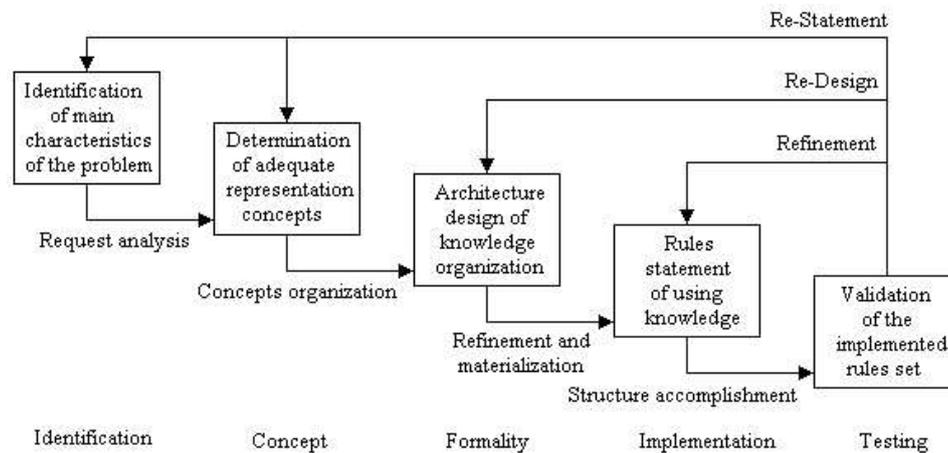
**Fig. 3:** Logic design.

### ES advantages:

- They are valuable collections of information
- They are indispensable without human expertise
- In some situation, they can be cheaper and more effective than human experts can
- They can be faster than human experts can
- If flexible, they can be easily up-dated
- They can be used to instruct new human experts
- At request, they can explain the premises and reasoning line.
- They treat the uncertainty into an explicit manner, which, unlike human experts, can be verified.

*Stages in the design and implementation of an ES:*

Expert systems are, in fact, particular cases of the *production systems*, which address to some domains with a very strait specialization. In fact, the larger the number of knowledge within a system is the efficient it acts. As human expert, ES has a sphere of competences limited only to a certain domain, usually, very strait, its functionality lying on the human reasoning pattern: starting from certain knowledge or facts, ES develops a series of inferences and reaches to a certain conclusion. Under the context, a synthetic definition of ES would be as follows *programs dedicated usually to a specific domain that try to emulate human experts' behavior.*

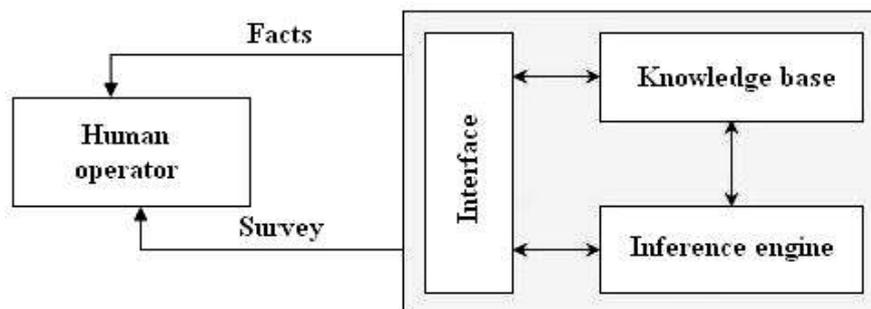


**Fig. 4:** ES implementation.

As a component of *production systems*, ES is one of the most used patterns for representing and control of knowledge. Within this terminology, the word *production* must not be confounded with which happens in factories and plants. Its significance can be translated according to the definition as the *production* of new facts added into knowledge base due to the appliance of these rules. A possible definition of the production system including ES referring to their structure could comprise the following elements:

- A set of rules, each rule has two components such as component *condition* that determines when the rule applies and component *consequence* that describes the action, which results by applying the rule. This set of rules form *rules base*.
- One or many databases contain the information describing the analyzed problem. This database contains initial information where new facts add resulted by applying the rules. This set of information forms *facts base*.
- A control mechanism or rules interpreter frequently named interference engine, which assures the stability of rules appliance order for the existent database. The selection of the rule that applies and solve the appeared conflicts when many rules can be applied simultaneously.
- Communication between operator and ES accomplishes by a specialized interface that assures the efficient exploitation and development of the ES. This interface allows the achievement of two important functions such as:
  - a) On one hand, at human operator demand ES can explain the reasoning it achieved. This is necessary because as complex and “praised” ES is, human operator cannot always accept “blindly” the solution proposed by ES but he wants to pursue and analyze the reasoning machine made.
  - b) On the other hand, in order ES develop by gathering experience it is necessary the modification of the old knowledge and addition of new ones into knowledge base.

The first two components form the so-called *knowledge base*. Representation and organization of knowledge base are two essential aspects for the correct functioning of ES. If it is desired for a ES to develop it is absolutely necessary that knowledge base is completely separated by the rest of the program that uses it (communication interface with the operator and interference engine). The interaction between human operator and ES is synthetic described in figure 5.



**Fig. 5:** Communication between human operator and expert system

Under the context of considering ES as formalism of the AI, this organization presents two big advantages such as:

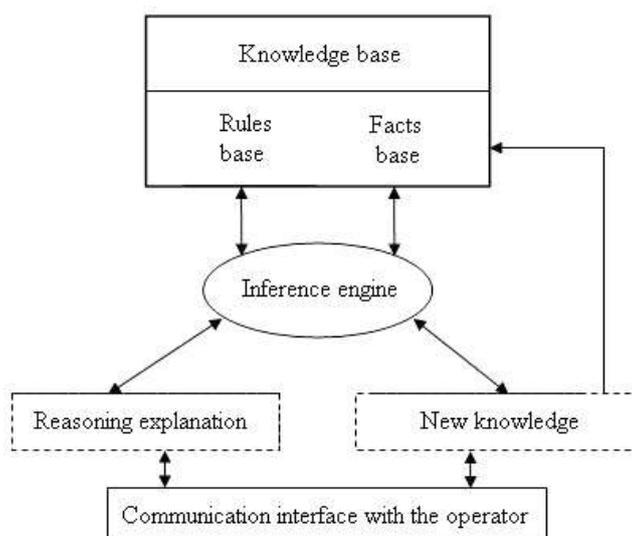
a) On one hand it represents a really inspired simulation of the intelligent processes with a dominant nature on information processing,

b) On the other hand, it assures the possibility of adding new rules without disturbing the system in assembly, property that responds very well to the statement according to which no intelligent system is definitive.

Summarizing the above definition, ES characterizes by the following attributes:

- Necessary knowledge refers to a relative strait domain and they are well specified.
- ES are underlying less on algorithm techniques and more on an important volume of knowledge from a specific domain.
- An ES can be built only with the help of a human expert open to spend an appreciable time to transfer its own expertise to the program. This knowledge transfer makes gradually by frequent interactions between human expert and program.
- The volume of necessary knowledge depends on problem. There can be situations when several dozens of rules and other situations are necessary to establish thousands of rules.
- The selection of the control structure for a particular ES depends on the specific of the problem.
- Knowledge is represented under declarative form by using usually a structure type IF...THEN... As a result, the majority of expert systems use *rules bases*.
- Knowledge base is clearly separated by the control mechanism of knowledge handling (inference engine).
- Communication with human operator makes through a relative complex interface, which assures the integration, communication, explanation and delivery of knowledge.
- In most cases, the interface consists in a specialized module meant for the modification of the existent knowledge and the acquisition of new knowledge for ES development.

The general structure of an ES that reflects these attributes is described in figure 6.



**Fig. 6:** General structure of an ES.

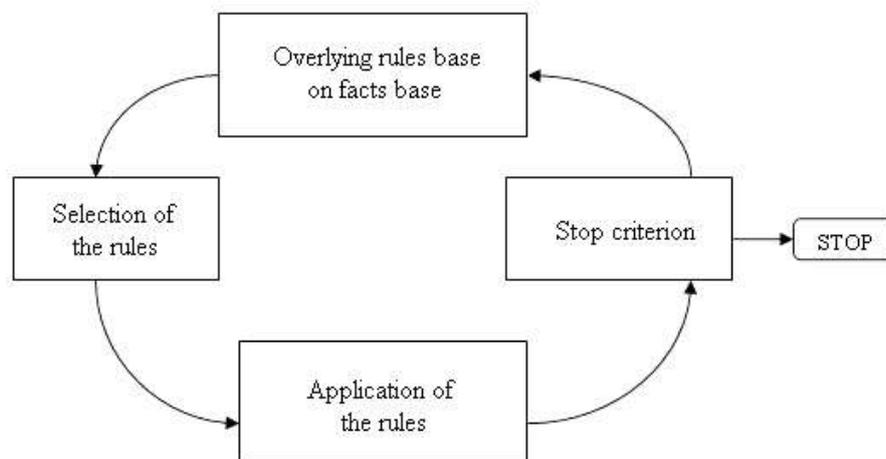
As for the proper functioning of an ES, the specific mechanism that underlies reasoning realized by program is inference. According to DEX definition, *inference* is a logic operation that passes from a statement to another one and where the last statement is deduces from the first one. Yet, many times ES are used in parallel with the interface and search techniques, where, at every turn, from the multitude of the rules defined at system level apply only one and once in a while two or most three rules.

Thus, the inference is equivalent to a deduction process that starts from the initial or final conditions, and, by the sequential appliance of some rules, it gets into desired state. Fortunately, in many situations building a set of rules that allow the appliance of pure inference is not possible and, as a result, reasoning row used by ES transforms into a search process. In consequence, intelligent search techniques represent all-important elements in ES functioning.

Inferences development parallel to search processes is controlled by inference engine that assures information handling from knowledge base by realizing four types of actions as follows

- a) Overlaying of the rules base over facts base to identify the applicable rules;
- b) Selection of the applied rules;
- c) Rules appliance;
- d) Verification of stop criterion.

Inference engines can use two types of inference such as *foreword chaining* (from initial state towards final state) or *backward chaining* (from final state towards initial state). In case of foreword chaining, inference engine controls the production/adding of new facts into facts base and in case of back ward chaining – it verifies certain hypothetical information established during the process of backward chaining.



**Fig. 7:** Functioning of inference engine.

Between the processes controlled by inference engine one of the most important and sensitive is the selection of rules that will be applied. Difficulty of this process lies in the fact that, at a certain moment, the database can contain facts that simultaneously satisfy the conditions of multiple rules; the decision to take is which rules will be applied. Inference engine functioning according to those four actions that it controls is described in figure 7.

#### *The analysis of expert systems:*

The analysis of expert systems – ES shows us that not the special module is connected with the knowledge of the domain. Knowledge implies both explicit knowledge and intrinsic (implicit) knowledge. Explicit knowledge are embodied in documentations, codes, standards, transferable or accessible procedures. Intrinsic knowledge implies both a professional culture and a constitutional one. They are found «hidden» inside man's mind, in its reasoning. These are harder to encode, communicate or free for access.

Accordingly, in order to approach diagnosis or analysis problems of the different Thermal Systems (TS) built artificial intelligence systems. The *comparison* between these three approach groups allows us the selection of the most appropriate work method.

**Table 1:** Comparison elements

Comparison elements	Case-based reasoning (RBC)	Neural Network (NN)	Rule-based reasoning (RBR)
Module of data building, their representation	Data regain for similar problems	Recognition of some valid models and standards	Rules type if-then
Module of data achievement	Old solved cases	Learning according to the learning algorithm. Input data	According to human experience and to experts' ideas within

Comparison elements	Case-based reasoning (RBC)	Neural Network (NN)	Rule-based reasoning (RBR)
		ponderosity	domain
Expert's procedure in solving the problem	Extraction of similarity cases from database	Recognition of the correlation cases between input-output measures and it learns the network	Step-by-step, logically
Construction of the analysis system	Easy to build but it needs time	Black box. No need for detailed knowledge in the domain	Difficulties in knowledge acquisition (data, standards, codes etc.)
Data renewal	Handy	By learning in a trained manner	Handy
Their understanding	Hard	Acceptable	Easy

The last researches bring light that the best approach is the accomplishment of a hybrid expert system where the modules can be built separately based on a proper inference engine.

#### Conclusions and perspectives of expert systems:

Even though, at the beginning, the followers of artificial intelligence promotion (AI) through expert systems hoped to develop some systems that would exceed through their performances the human experts, this desire did not fulfill, at least not now. This happened because knowledge acquisition within an ES is not a very simple process, as it may seem at a first glance. Why this process would be so complicated? Probably the easiest answer is that human expert gains, in time, not only knowledge but also *experience*. Knowledge itself allows the development of some reasoning based on rules (as in ES case). On another hand, *experience* allows the development of some *subliminal* reasoning (not accessible yet by computing programs), which in day-to-day life would translate by *instinct* or *inspiration*. Due to this, the majority of ES developed so far limited to relative tight domains that can be quantified in a rigorous and direct manner.

#### REFERENCES

- [1] Aamodt, A., E. Plaza, 1994. *AI Com-Artificial intelligence Communications*, IOS Press, 7(1): 39-59.
- [2] Alberg, H., 2005. *Simulation of Welding and Heat Treatment Modelling and Validation*, Doctoral Thesis., : 33 ISSN: 1402-1544, ISRN: LTU-DT - -05/33 -SE.
- [3] ASM Handbook - Heat Treatments, 1994. IV, U.S.A..
- [4] Aylene Jonathan, 2004. *Megabytes for metals: development of computer applications in the iron and steel industry*, Ironmaking and Steelmaking, 31: 6.
- [5] Friedmann, E.– Hiu, 2003. *Jess the Rule Engine for the Java Platform*, CA, USA.
- [6] Han J. and M. Kamber, 2001. *Data Mining: Concepts and Techniques*, Morgan Kaufman Publisher, San Francisco, Ca, USA.
- [7] Hopgood Adrian, A., 2005. *The State of Artificial Intelligence*, *Advances in Computers*, 65: 1-75.
- [8] Kang, J., Y. Rong, W. Wang, 2004. "Numerical simulation of heat transfer in loaded heat treatment furnaces", *Journal of Physics*, 4(120): 545-553.
- [9] Kolonder, 1992. Riesbeck and Schank, *An introduction to case-based reasoning*, *Artificial Intelligence Review*, 6(1): 3-34.
- [10] Kwang Hyuk Im, Sang Chan Park, 2006. *Case-based reasoning and neural network expert system for personalization*, *Expert Systems with Applications*, 32: 77-85.
- [11] Kwang Hyuk Im, Sang Chan Park, 2007. *Case-based reasoning and neural network expert system for personalization*, *Expert Systems with Applications.*, 32: 77-85.
- [12] Lilantha Samaranayake, 2003. *Distributed Control of Electric Drives via Ethernet*, TRITA-ETS-2003-09, ISSN 1650{674xISRN KTH/EME/R 0305-SE}, Stockholm.
- [13] Owhadi, J., Hedjazi, and P. Davami, 1998. *Materials Science and Technology*, 14: 245-250.
- [14] Romero Carlos, E., Jiefeng Shan, 2005. *Development of an artificial network based software for prediction of power plant canal water discharge temperature*, *Expert Systems with Applications.*, 29: 835-838.
- [15] Saha Podder, A.S., A. Pandit, D. Murugaiyan, Bhattacharjee and R.K. Ray, 2007. *Phase transformation behaviour in two C-Mn-Si based steels under different cooling rates*, *Ironmaking and Steelmaking*, 34: 1.
- [16] Shin, C.K., U.T. Yun, H.K. Kim, & S.C. Park, 2000. *A hybrid approach of neural network and memory-based learning to data mining*, *International Journal of IEEE Transactions on Neural Networks*, 11(3): 637-646.
- [17] Shin, C.K., U.T. Yun, H.K. Kim, & S.C. Park, 2000. *A hybrid approach of neural network and memory-based learning to data mining*, *International Journal of IEEE Transactions on Neural Networks*, 11(3): 637-646.
- [18] Shu-Hsien Liao, 2005. *Expert System Methodologies and Applications-a decade review from 1995 to 2004*, *Expert Systems with Applications.*, 28: 93-103.
- [19] Singh, A., et al. 2004. *Predicting microstructural evolution and yield strength of microalloyed hot rolled steel plate*, *Materials Science and technology*, 20: 1317.

- [20] Topolov, E.V., V.I. Panferov, 1991. Câteva probleme de realizare a automatizării cuptoarelor industriale, Cernaia Metalurgii, nr., 2: 93-96.
- [21] Varde Aparna, S., Mohammed Maniruzzaman, Elke A. Rundensteiner and Richard D. Sisson Jr., 2003. The Quench Miner Expert Syatem for Quenching and Distorsion Control, Worcester Polytechnic Institute (WPI), USA.
- [22] Vizureanu, P., 2006. *Experimental Programming in Materials Science*, Mirea Publishing House, Moscow, 116: ISBN 5-7339-0601-4.
- [23] Vizureanu, P., 2009. *Echipamente și instalații de încălzire*, Editura PIM, Iași, 2009, 316pg., ISBN 978-606-520-349-5.
- [24] Vizureanu, P., A. Andreescu, N. Iftimie, A. Savin, R. Steigmann, S. Leițoiu, R. Grimberg, 2007. *Neuro-fuzzy expert systems for prediction of mechanical properties induced by thermal treatments*, Buletin I.P.Iași, tom LIII (LVII), fasc. 2, secția Știința și Ingineria Materialelor, pp: 45-52.
- [25] Vizureanu, P., M. Ștefan, C. Baci, I. Ioniță, 2008. *Baze de date și sisteme expert în selecția și proiectarea materialelor*, vol. II, Editura Tehnopress, Iași, 2008, 262 pg. (40 rânduri/pg.) ISBN 978-973-702-515-9.
- [26] Vizureanu, P., 2010. - editor, *Expert Systems*, published by Intech, Vukovar, Croatia, 238 pages, ISBN 978-953-307-032-2.
- [27] Vizureanu, P., 2011. - editor, *Expert Systems for Human, Materials and Automation*, published by InTech, Rijeka, Croatia, 392 pages, ISBN 978-953-307-334-7.
- [28] Vizureanu, P., 2012. – editor, *Advances in Expert Systems*, published by Intech, Rijeka, Croatia, 120 pages, ISBN 978-953-51-0888-7.
- [29] Xu Xiaoli, Wu Guoxin and Shi Yongchao, 2005. *Development of intelligent system of thermal analysis Instrument*, Journal of Physics: Conference Series., 13: 59-62.
- [30] Yescas, M.A., 2003. *Prediction of the Vickers Hardness in austempered ductil iron using neural networks*, Int.J.Cast Metals Res., 15: 513-521.