EXPERT SYSTEMS USED IN INDUSTRIAL PRODUCTION MANAGEMENT

Dima I.C., Man M. ,Grabara I. , Ciurea V.*

Abstract: In the conditions of computing the human society, the operational management activities can be improved by using artificial intelligence. Therefore, an expert system is proposed, for the metallurgical industry, for the casting activity for parts necessary in mining industry.

Keywords: expert systems, artificial intelligence, interface, search engine, implementing the expert system.

Introduction

The efficient operation of the integral production systems is based on artificial reasoning, as condition for simulating the human reasoning and supplying the expert's essential role in an actual domain. The expert system represents a major component of *artificial intelligence*, by means of which the knowledge of some experts in that domain are stored and, by means of a declarative approach, can be then dynamically exploited by an artificial mechanism, simulator of natural rationing triggered at the level of the human brain. The phrase *expert system* generally evokes the new techniques of management in various activity domains and which are currently assimilated through the notion "*contents of a database management*".

Contents of research

The notion of "expert system" refers to a software that uses all knowledge specific to the various activity domains during the process of elaborating a resolution for each problem that may intervene within a well defined domain. Therefore, the expert system *Aims at gathering the experience and rationing of a human expert for replacing it.* This accumulation represents the formation foundation of the knowledge base, which is one of the basic components of these systems.
The expert system is an intelligent system based on the symbolic representation of knowing, implemented on a hardware structure specific to the application, which processes a lot of knowledge for solving special issues about activities that are difficult to examine.
Regardless of the definition of the expert system, there are four features which classifies a software as expert system. It works at the expert level of competence; it uses an inference mechanism for accomplishing deduction; the expertise

* Prof. Univ. dr Ioan Constantin Dima, PhD. Ciurea Vergil**, "Valahia" University of Targoviste, Romania,** ✉ corresponding author: dima.ioan_constantin@yahoo.com,
Prof. Univ. dr Mariana Man, Universitatea din Petroşani, Romania**,**
Dr. Iwona Grabara, Czestochowa University of technology, Faculty of Management

performed is based on knowledge specially gained; programming such systems involves the presentation of the knowledge of some experts in the domain, this knowledge could be kept in the database for future use.
The architecture of any expert system must contain at least three main modules, which determine the so-called *essential system*, in figure no. 1, an expert system is represented, adapted to the necessities connected to the operational management.

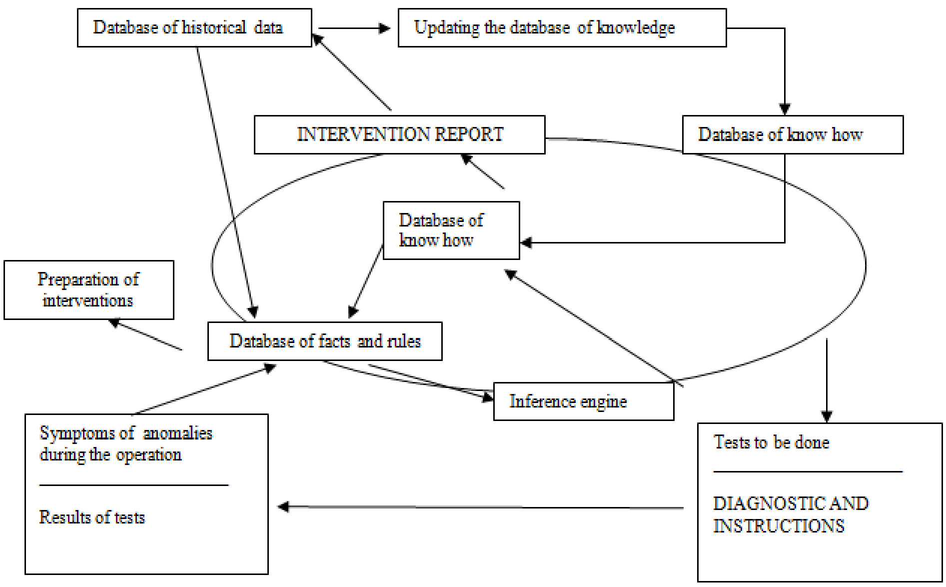

Figure 1. The expert system for the operational management

The schematic representation of an expert system for the operational management.
The main modules of the expert system are:

- *the knowledge database* – represents the component which stores the system's permanent specialised knowledge, provided by the expert in that respective domain. The knowledge database is formed by the *database of facts* and *the database of rules*, integrating the knowledge related to solving a problem in a given domain, the knowledge consisting of facts (assembly of data related to the problem) and rules (laws, methods and elements of rationing applicable to facts) treated by means of an engine of inferences with the aim to accomplish an objective requested through the problem dealt with,
- *the knowledge purchase module* allows the formation of a system's knowledge database. Usually, the knowledge specific to the domain is taken over from human experts by means of a specialist in the engineering of knowing. Another modality of getting knowledge specific to the domain is to automatically generate this knowledge using various methods of learning,

- *the database of rules and the database of facts* are elementary components of the knowledge database. *The database of rules* is formed by the manifold of relations representing the expert's knowledge and fulfils the following meanings: it consists of the rules which the connections between facts are specified by; the rules use initial (known) facts for deducting new facts based on inductive and deductive processes (in the situation where the rules may provide the direction and control of the manner which other rules are applied, the concept of *metarules* is highlighted). *The database of facts* consists of all facts which the creator of the expert system has enclosed in it or which are deducted during the rationing (of the inference process). The database of facts consists of an assembly of structures of complex data charged with a certain meaning, generically called "*facts*", related to a particular problem which a resolution is requested for through the system of a database of knowledge. The facts represent the assembly of the affirmative knowledge necessary to treat the domain dealt with,
- *the inference engine* is destined to exploiting the assembly of knowledge for solving the problems and it represents the actual processing element in the expert systems, which activates the corresponding knowledge in the knowledge database, starting from facts (problem input data), thusly forming rationing which lead to new fact called output facts. in conclusion, the interference engine is a software implementing algorithms of ratiocinations of *deductive* (directed by facts), *inductive* (directed by aims) and *mixed* (featured by the course of an inductive ratiocination, followed by a deductive ratiocination) types, but which does not depend on the knowledge database,
- *the inference mechanism* is the executive part of the expert system that uses the codified knowledge from the database of knowledge for creating inferences and drawing conclusions. It is a software which allows: exploiting the know-how database, coordinating the ratiocination for deducting new facts which would represent the new know-how database of the system, dynamically creating and explaining ratiocination, adopting resolutions on rules that must be triggered and on order where they are applied, procuring new knowledge. In fact, the inference mechanism is the core of an expert system which performs deductions in the process of solving a problem, by covering and eventually changing and adjusting the elements from the know-how database.

Regardless of the ratiocination mode used, *the basic cycle* of an engine of interferences carries four stages: *the selection* extracts from the database of rules and from the one of facts all information characteristic to the subdomain of solving the problem; the *filter* consists in comparing the premises, the rules previously selected to the facts featuring the issue to be solved, for determining the submanifold of applicable rules and on must be chosen for being performed; *the execution itself* of a rule consists in adding one or more facts into the database. It is also possible that at this stage, external procedures would apply, respectively to have access to the database, to processors of tables or to questions asked to the user.

The occurrence of IT equipment and efficient software, which may be purchased for low prices, allow each manager of an industrial company to take into account the use of IT use, without incurring too big of a financial risk. In practice, there are several modalities of choosing and using an expert system. Thusly, a first choice must follow the possibility of the expert system to cover the time gap “t” that exists between the duration necessary to getting an answer and the duration necessary to forming knowledge at the time when it is questioned.

The starting point for such a step was to know the main features of the casting technology, as first modality of getting familiar with the process itself of performing the operations necessary to the cast items in the finished form, for costs as low as possible and in the conditions of minimising the risks of there occurring damages.

Thusly, *casting represents the technological process of making parts for mining machines, by solidifying the molten material in the cavity of a mold.* Compared to other technologies, casting represents the following advantages: the possibility to obtain the parts with complex configuration, with a shape as close as possible to the finished one; the small amount of processing addition; the use of machines of simple and cheap construction, reusing the waste of materials by melting, which have resulted during the technological process or partial recovery of the value of scraps, lower unitary costs of the cast parts than of those made by other procedures etc. between the disadvantages associated to this technological process, the most frequent are: high probabilities of obtaining parts with defects; probabilities oflower resistance compared to the wrought parts; the use of some considerable amounts of materials for obtaining the parts etc.

Making the shapes represents the printing operation of the foundry pattern in the formation mixture. After extracting it, the pattern remains, where the melted metal is poured in order to obtain the parts. This is the main operation in the technological process of obtaining the cast parts and decisively conditions their quality parameters. Making the shapes can be performed *manually* (in frames, in soil or by patterns) or *mechanised* (by throwing, by pressing with a membrane, by shaking and pressing, by blasting etc.). At S.C. UTILAJUL S.A., the classical method is used, that of manual formation in frames, featured by low costs related to the documentation, shaping materials and tools under the conditions of low accuracy and quality of the cast surfaces.

Drying the shapes and cores represents the operation by means of which they are subject to heating in order to remove the water from the formation mixtures and to increase the bonding capacity of the binders. By drying, a considerable increase of the mechanical resistance of the formation mixture is performed, as well as the decrease of permeability and limitation of the gas amount which develop in the moulds during casting. At S.C. UTILAJUL S.A., the sand dryer on fluidising bed is used for drying the cores, as well as for drying the moulds.

Assembling the moulds for casting consists in assembling the semi-moulds and cores into a single system. The cores and mould cavity are supported by means of stamps, and when these are missing or are too long, it is done by means of wood supports. After assembling the moulds and elaborating the alloys, then follows the *casting itself* into moulds. The melted metal is taken from the casting pot and directed into the cavity of the mould, by means of the *casting line*.

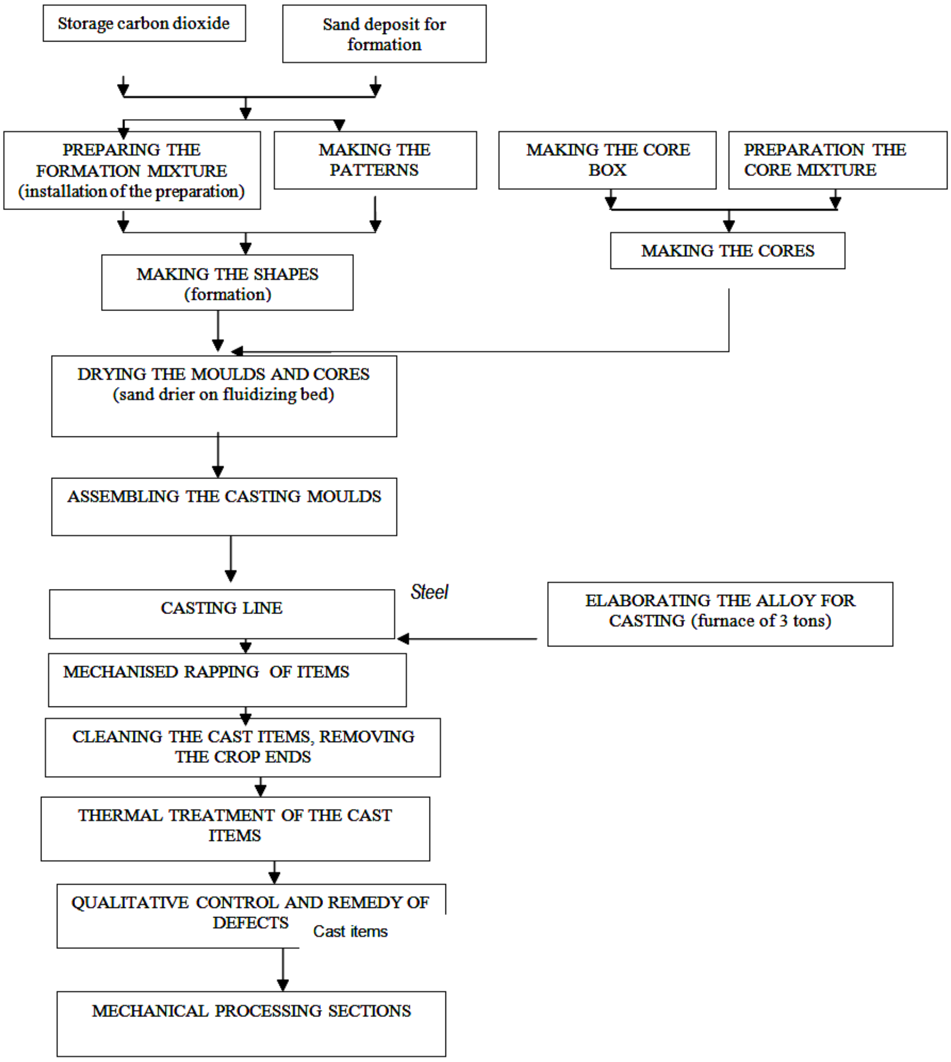

Figure 2. The diagram of the technological process for obtaining the parts cast at S.C. UTILAJUL S.A.

Rapping is the operation by means of which the item is taken out from the shaping frame and most of the formation mixture is removed from the outside and the core mixture from the inner cavities of the items. Rapping the mould is done after the metal has solidified and cooled down at a temperature where no more defect dangers can occur, by cooling the item more rapidly in the air.

Cleaning is the operation of removing the formation mixture adherent to the cast items. Usually, cleaning is done in several stages: *superficial cleaning* done for removing the waste heads; *preliminary cleaning* consisting in removing as much as possible the formation mixture from the item; *final cleaning* which is done after the thermal treatments applied and consists in removing all materials which are still on the surface of the item (formation mixture remained or oxides formed during the thermal treatment). Final mechanised cleaning is done at S.C. UTILAJUL S.A. by means of the *sandblast machines*, which direct an abrasive jet over the items which are to be subject to this process.

Removing the waste heads represents the operation of cleaning away the crop ends and the casting network from item A.

Removing burrs from the cast item implies the cleaning of the excess of material which appears on the plane of shape saturation.

Thermal treatments are applied to the cast items, with the following aims: removing the internal strains occurred when casting; relieving the processing by chip removal; improving some mechanical properties when no other thermal treatments are performed anymore or when the structure is to be prepared for obtaining some better properties for future thermal treatments.

The probability of there occurring defects in foundry is higher than in other activity sectors, reason for which the qualitative control must be run more intensely. Taking into account all of these, qualitative control in foundries is of two types: *preliminary control* applied on materials used and operations before casting the item, in order to eliminate the possibilities of defects to occur, respectively the *final control*, which is done on the cast item and must be performed in two stages. During the last stage, the item is monitored, starting from rapping and going through all other operations, in order to find out potential defects and for adopting as quickly as possible the adequate measures. During the second stage, the control of the items is done, after all operations for obtaining the gross cast item have finished, in order to retain those cast items which do not correspond to mechanical processing, respectively, to future use.

Taking into account all of the above, an *expert system is elaborated below for managing the casting technological process for metals at S.C. UTILAJUL S.A.*

Frame-software preceding the elaboration of the expert system for managing the technological process of casting the metals at S.C. UTILAJUL S.A.

I. Stating the components which will form the expert system base of rules and base of facts.

<u>Step 1.</u> Defining the arguments that will be used by the predicates of the expert system and namely: the type of the date used by the system from the data list will define economical categories, such as: existence (is), attributions (has), making the pattern (is_in), preparation of the moulding compound (is_on), moulding sand deposit (is_by), costs (cost) and needs (needs).

Step 2. Defining the predicates, meaning the calculation rules and questions taking into account the definitions from step 1.
Step 3. Stating the standards to fulfil for the operation of the base of rules and base of facts for the expert system. These standards can be schematically represented in the following logical diagram:
Question 1: Is the preparation of the moulding compound unsatisfactory?
It displays: Is x unsatisfactory?
Question 2: Is it in the moulding sand deposit?
It displays: Is x in the moulding sand deposit?
Question 3: Is the pattern made?
It displays: Is x made?
Question 4: Is the pattern good?
It displays: Is x good?
Question 5: Is the cost greater than 100?
It displays: Is the cost x greater than 100?

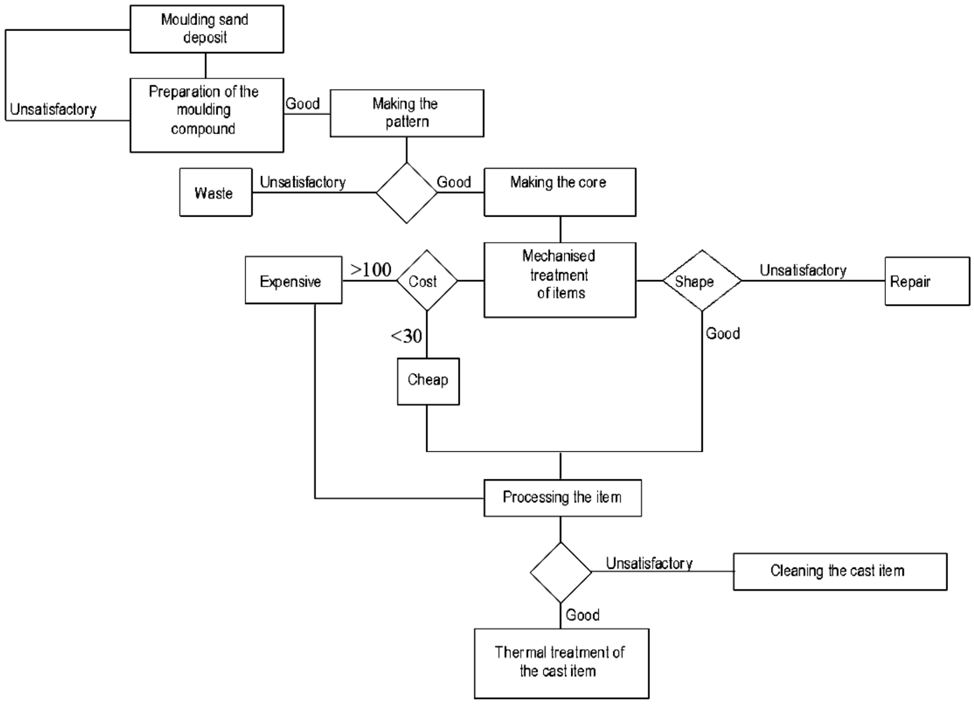

Figure 3. Logical diagram

Question 6: Is the cost lower than 30?
It displays: Is the cost x lower than 30?
Question 7: Must it be repaired?
It displays: Must x be repaired?

Question 8: Is x treated mechanised?
It displays: Is x treated mechanised?
Question 9: Is x subject to thermal treatment?
It displays: Is x subject to thermal treatment?
Question 10: Is it at the melting limit?
It displays: Is x at the melting limit?
Question 11: Is it well processed?
It displays: Is x good for processing?

II. Stating the components of the inference motor and user interface.
Step 1. Defining the arguments that will be used by the predicate of the expert system and namely: using entirely the files from the database (of facts).
Step 2. Defining the predicates, meaning the rules according to which the expert system inference motor works, taking into account the definitions from step 1 and namely: defining the process (proc_user), triggering the technological process (start_exp), reading the characters defining the technological process (read_char), defining the interference (interference), complying with the rules of the technological process (process_rule), stating whether the rules of the process are or are not complied with (getresponse), validating the received response (validresponse), fulfilling the first stage of the process (get_first), deleting the data (delete), verifying the response (check_ans), making the base of facts (add_fact), verifying the facts (check_fact), analysing the process (process_why), displayed rule (display_rule), clearing the base of facts (clear_facts), performing the iterative process for checking the fulfilment of all stages of the technological process of making the finished product (moulded item) (repeat), converting the results obtained from checking the stages of the technological process into data (convert) that will be used at the next stage regarding the analysis of the degree of fulfilling the standards featuring the technological process.
Step 3. Stating the standards to fulfil for the operation of the inference engine of the expert system and presenting them in a logical diagram.
start_exp:
Displaying the text “Expert system” in a user window
It displays: „i-init, a-add facts”
nl – predicate returning true and which has as effect the transition to a new line
It displays: „q-quit, r-run”, nl
It displays: „Enter your option: (i/a/q/r)”
It reads the entered character
If the character entered is q then the process ends.
If the character entered is i
It displays: “Does it delete all facts?”
It reads the character and if it is y, it deletes all facts.
If the character entered is a
It displays: “Enter a fact:”

It reads S
It converts S into T, it adds T to the base of facts.
If the character entered is r
It displays: “What is your query?”
It reads the question
It converts the query into Term.
Clearing the base of facts
Adding a fact T or, if not, adding the clause
It displays: “The fact already exists", nl
It converts S into T:
It opens the file “convt.dat” for writing
It displays S, it closes the destination file
It opens the file “convt.dat” for reading
It reads the destination file
It closes the destination file, it reads from the keyboard.
Process (Question):
Interference
It displays: “Was your query verified with probability?”
Process (Question):
It displays: “Your query cannot be verified”
Interference:
It verifies whether the fact complies with the rules of the technological process
Interference:
It verifies whether the fact complies with the rules of the technological process
If yes, it is added to base of facts, if not, it is deleted
Complying with the rules of the technological process
If the first stage is fulfilled
Interference
Response R:
It reads Ask
It compares Ask to Rep
R = Rep
Anonymous response:
It displays: “Please try another response”
Response R
Verifying the response
Verifying the action:
It displays: “The action used is Fact”
Verifying the action:
Question
Reception of the response
Verifying the response
If the response is Y, the action is added into the base of facts

Verifying the response
    Analysing the process
    Verifying the action
Analysing the process
Analysing the process end-to-end
    Analysing the end process
    Rule displayed peak
Rule displayed peak:
    It displays: “Analysing the process:”
It adds to the base of facts
Fulfilling the first stage of the process (peak)
Deletion end-to-end
It deletes the sign end-to-end
It deletes the last sign (end)
Repetition
    Repetition

Summary

The expert system for improving the operational management related to the cast items is especially destined to assisting the exploitation and maintenance personnel when diagnosing the complex defects which may occur during the course of this process and for the efficiency of the technical measures that must be taken after the occurrence of those respective disfunctionalities. This system has the advantage of exploiting the memory of the past events and the experience of more experts whom participated at founding the system’s database of know how, without comprising them into an expert system, such knowledge cannot be transmitted to those who ensure the use of the system forward.
The complex mutations that occur in the current industrial context have determined companies to revolutionise their strategies, to search permanent innovation for keeping and/or winning some new market segments. All these occur during a period of *“explosion"* of the IT systems, highlighting the need of integrating all company’s activities by means of the computer. As *strategic option* in the domain of operational management, *computing the activity by using the expert systems* represents a pragmatic modality of improvement, which must be explored thenceforth at S.C. UTILAJUL S.A., due to some incontestable advantages such as: *performance* – the expert systems do not lose their knowledge as time passes by, being capable of continuously working; *the possibility of being multiplied* – many copies of an expert system may be easily done, while creating new human experts represents a long and expensive process; *efficiency* – implies low costs compared to performing the expertises by the human specialists; *consistency* – similar actions are processed and treated in the same manner; *objectivity* – the system is not accessible as opposed to human experts whom can be subjective; *documentation* –

an expert system may provide a permanent documentation of the decision process; high *working speed* etc.

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SYSTEMY EKSPERCKIE WYKORZYSTYWANE W ZARZĄDZANIU PRODUKCJĄ PRZEMYSŁOWĄ

Streszczenie: Sztuczna inteligencja może przyczynić się do poprawy działań związanych z zarządzaniem operacyjnym w przypadku informatyzacji społeczeństwa. W związku z powyższym, w artykule zaproponowano wykorzystanie systemu eksperckiego w przemyśle metalurgicznym, szczególnie w procesach odlewania części niezbędnych w przemyśle kopalnianym.

专家系统在工业生产管理中的应用

摘要：在当今人类社会的条件下，人工智能可以运用于经营管理活动，从而改善经营管理活动。因此，一个目标冶金工业，铸造工业以及一些小型工业领域的专家系统正在计划当中。