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EXPERT SYSTEMS FOR STEAM TURBINES DRIVING

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Thermoenergetic processes aided management, efficient and real-time, at turbogenerator level involve high rapidity feedback and more that, processes prediction to establish evolution sense to out of range function, before reach them. So, elimination and interactive correction of errors introduces by automation elements must by continuos, so for process stability states like for transitory states, where parameters variation rapidity involve rapidity of data and errors processing.

To create an efficient, fast and complex system for driving and surveillance of a turbogenerator group, or a steam turbine, involve using the computing technology and a specialised software's for data analyse and computing. That system, dedicate for an equipment is named expert system. Create, using and develop of a expert system involve to create an analyse, diagnose and prediction ensemble to be capable to oversee and co-ordinate the machine or a group of the machines and offer to user a complex view about drive process and so help and faster solve solutions, if an damage appears or if the process follow to go through out of range limit.

Characteristic expert system functions can be define as a basic collection of rules for software development. Analysis addicted software will read, process, storage, analyse and proceed so, one certain parameter from process to came information as analysed will be return back into process by execution organs or will be transform into a alpha numerical or graphical information for users. The expert system must guide the process evolution into the predicted evolution range.

Maybe the most important characteristic of an expert system, what separate it of an conventional automation feed-back system, is that the expert system will be into a continuous developing by continuously storage of malfunctions parameters and create and store, based it, new procedures to solve the problems.

Software expert system development platform consists into a collection of functions, methods and procedures that by hardware components can oversee and control the process. Software platform is a machine program process dedicate, developed under a flexible programming tool who can give possibility to modify, develop, add, or eliminate procedures and functions writes for process managing.

Case of fast evolution processes is necessary to use a multi-tasking software platform so that every stage of process can be watch.

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1. The expert system characteristics

By expert system we understand o complex hardware and software compound which allow an almost total control of a certain physical system, its functioning is based on the evolution of one or more processes, dependents or independents, bound by certain state or running equations.

The hardware components consist of the central dedicated unit, connected through interfaces at the sensors and transducers, through which the system gets data from the analyzed process, or at output regulators through which the system remand the data into the process, self-regulating, so that it remains in the proposed running parameters.

The software component of the system is composed from a complex package of complex applications, with exact and well determined roles, represented by all the procedures and functions through which the process parameters are valued, analyzed, stored, processed and converted to a rational elements mathematic form. Also, the software component of the expert system can have communication protocols writhed especially for certain interface devices.

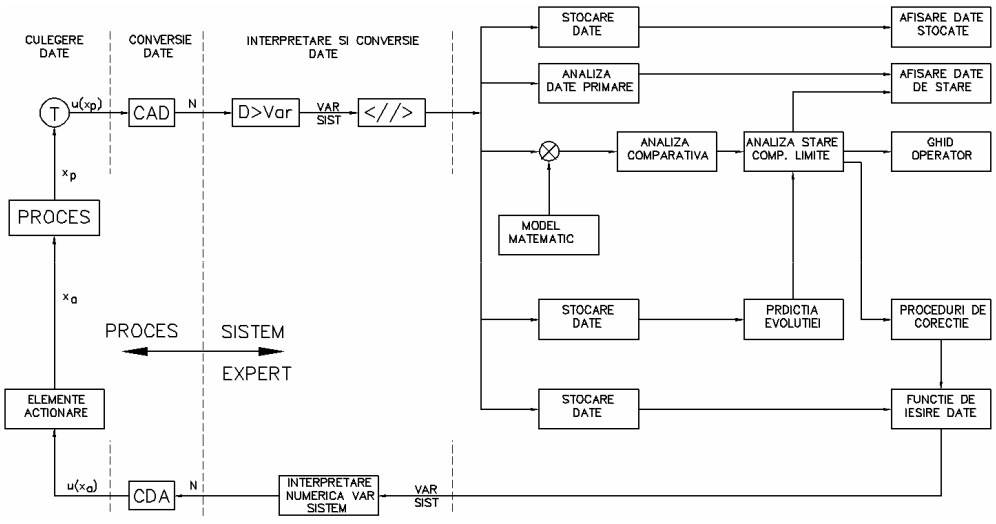

Fig. 1 The block diagram of an expert system

In terms of the grade of interaction between the expert system and the monitored physical system, they can be defined two big categories:

Open expert systems: They are expert systems that do not act directly on the development of the processes, having the role of processing, analyzing and storage the static and dynamic parameters of the process, generating situations, dispatches and warnings, based on which the human operator takes decisions and acts in consequence.

Closed expert systems: They are expert systems that are directly implicated in the supervision activities as well as in the direct running of the process, working after the principle of the reaction loop, keeping the running parameters of the process inside the imposed limits, in terms of the inlet values of the parameters. A well settle, closed expert system, will be able to "intuit" the course of the process evolution, keeping it from reaching the warning limits.

The difference between the two systems, the close one and the open one, consist in the role played by the human operator in the analysis-execution chain. For the open expert systems, the human operator role in the evolution of the process is decisive, he's decision of intervening or not (based on the information given by the system) is the one that will bring the process at the optime state of functioning, or at stability.

In the case of close expert systems the role of human operator is reduced at supervising the system and not at effectively controlling the process, like in the case of open expert systems.

Because there is no perfect system, because all the possibilities of process evolution at the transition between two states can never be take into account, is suggest, like a additional security measure, the direct or indirect intervention, of the human operator on the process, through the execution elements.

2. The expert system functions

The functions of an expert system can be define like a collection of rules based on which the analysis software can read, processing, storage, analyze and actuate in consequence, so that a certain parameter take from the process, can become a viable information, which, when analyzed can be transformed in a reference and/or execution parameter and to return into the process by means of the execution organ (directly, for the close systems, or indirectly, through the human operator, in the case of open systems) and to get to the establishing of the process evolution, inside the initial establish parameters.

2.1 The process data collecting function can be considered an extern function of the system, because it is realized by the external components of the system, transducers, which can be:

transducers for analectic measures: of pressure, temperature, vibrations, flow rate

transducers for electric measures: voltage, current, frequency, etc.

This function purpose is collecting information about the functional parameters of the process and converting them into a digital value of certain structure. The data volume collected by the automat system in the time unit is dependent of the sampling frequency; a high sampling velocity leads to a most real summarizing of the state parameters evolution.

Mathematic the conversion of an analectic measure in an electric measure can be written:

$$u(x_p)=f(x_p) \quad (1)$$

were: x_p - analectic measure taken from the process by the transducer; $u(x_p)$ - electric measure generated by the transducer base on the analectic measure; $f(x_p)$ - the transducer conversion function;

In case the transducer realizes also the conversion into a digital form of the analectic measure, the conversion function will have the form:

$$N_{xp}=f_d(u(x_p))=f_d(f(x_p)) \quad (2)$$

were: N_{xp} - the digital representation of the analectic measure;
f_d - the analog-digital conversion function of the transducer;

2.2 The data conversion function can also be consider an extern function of the system, its purpose is the conversion of analog or digital information, received from the transducers, into a digital information of a certain structure, interpretable by the mathematic methods of the expert system.

2.3 Data correction function is the first intern function of an expert system, realizing the correction of the digital data, in the expert system form, received from the process trough the conversion block. The correction of the inlet data is made through specific procedures which allow for the accuracy class of the transducer, the conversion deviation of the Analog-Digital Converter, the influences of the environmental factors, like the temperature variation, humidity, etc. The correction function can greatly reduce the measurement error, in the case of exact knowledge of the dynamic behavior of the inlet, transport and conversion of the data chain elements, in term of technical parameters and environment.

2.4 The data interpretation function has like objective to bring the inlet data to a form that will represent pertinent information, easily interpretable by a human operator. The data interpretation function, is the graph generator function, numeric or graphic indications, dispatches, warnings, etc. The data interpretation function is the function that makes the connection between the automat system and the human operator, offering him the information in the form that he needs for supervising the development of the processes at which the system is connected.

2.5 The data storing and analyzing function has like objective the data received from the process storage on storage supports, into a numeric high efficient form, so that the information collected in time can be consulted afterwards in order to analyze the evolution of the process in time, at short, average and even long term. The storage and analysation of the data on a long

term is the most efficient method for raising the real energetic characteristic of the installation, because it is analyzed the real evolution of the process or processes in time, not the mathematic approximation of the modeless. The data analysis function purpose is also the comparison of the data with the imposed variation limits, it does the statistic tracing of the process, and generate warnings in the case in which the variation limits are reach or overdue.

2.6 The function for comparing the data received from the process with the data from the mathematic model realize the comparison between the real process evolution and the evolution of a theoretic process generated by the mathematic model based on certain imposed functioning conditions, of which characteristics form a base of reference for the real functioning of the process evolution. The mathematic model will attend to the theoretic parameters, which the process shod reach, computed based on the real data, collected in functioning time. The computed and the real, measured parameters, are compared and related and the difference is kept under continuous observation.

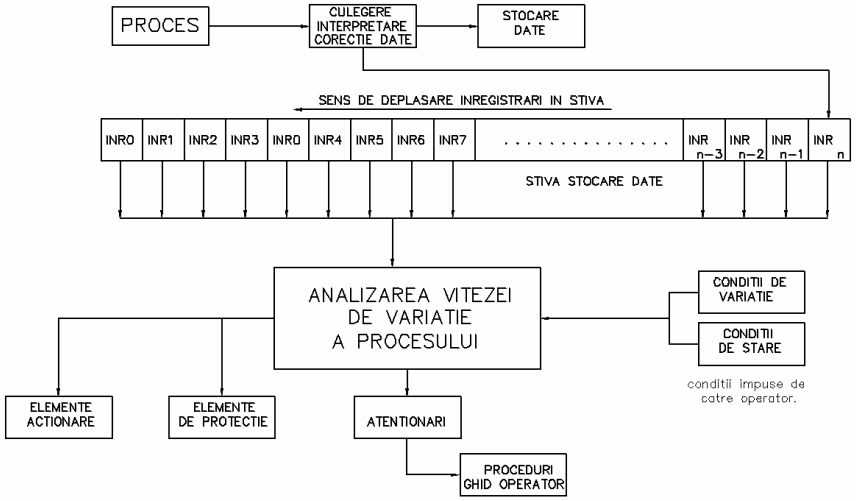

Fig. 2 The routine for process evolution prediction.

A constant difference indicates a normal functioning of the installation, without deviations. The appearance of variations of the differences between the theoretic and the real parameters indicates that inside the installation are appearing structural modifications, modifications that actuate on the process evolution by modifying its state parameters.

2.7 The prediction of the process evolution function realize the analysis of the process in a dynamic regime, being able, on probability-statistically bases, to anticipate the most probable state of process evolution.

The process evolution prediction method is based on the surveillance of the state parameters of the process variation on well established time intervals. The state parameters values are storage inside a pile of sufficiently great dimensions in order to ensure a representative set of values, values that will be continuous refreshed, at every new sampling of the process. The expert system will continuous monitoring the values of the parameters storage into the pile and will observe there variation velocity, as well as the probability for the ulterior evolution to develop in normal conditions or through functional instability points.

This function is very useful because, if it is based on a good mathematic apparatus, the study of the regression line associated to the process can anticipate in time its evolution in a wrong direction, with the possibility of actuate on the parameter before the process reaches the variation limits.

2.8 Operator guide function represents the fast assistance function, for the operator, which helps him to resolve in a short time a process malfunction problem. This function can generate a complete dispatch on the process problem resolution, or, based on the implication grade of the expert system in the process running, can actuate directly on certain process parameters, in order to stabilize the functioning and to reestablish the process inside the normal variation limits.

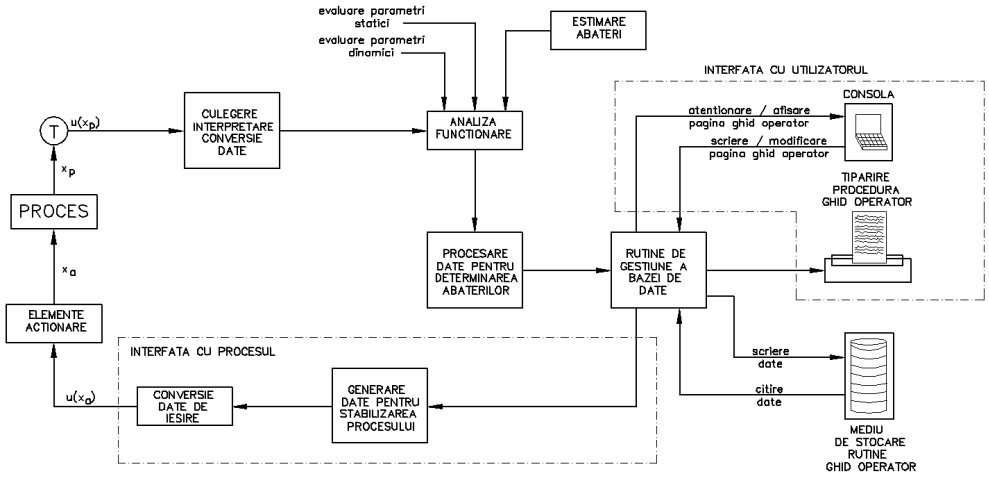

Fig. 3 The realization at the expert system level of the operator guide function.

Based on a powerful collection of variation limits and imposed situations, the functioning analysation and derivation estimation routines (fig. 3) will generate, in the presence of certain disturbed regimes, through the data processing blocks, special conditions for disturbed situations functioning, based on which the administrative routines block of the data base will solve the existing problem, if it is known. In case that the existing problem is not known, the state of the process

parameters at the appearance of the problem is memorized and the system will expect the human operator to introduce the solving procedure.

Attached to the administrative structures of the process, the operator guide function will be conceive like a function for continuous development of the expert system, the distress or abnormal functioning situations collection being in a continuous actualization, as well as the assistance routines collection.

2.9 The optimization of the process functioning function realize the evolution scenario of the process to obtain a maximum efficiency, with minimum consumes, based on the real energetic characteristics, rise based on the state parameters information, readied directly from the process. The updating of the energetic characteristics at certain intervals of time reduces the data interpretation errors, taking into account that the functioning parameters of every real system are changing in time because of the ageing, the reparations and certain modifications of the basic circuit.

The continuous parameterization of the process permits the observation in time of the optime point movement evolution and the continuous correction of it, so that in every moment, the expert system to know with great precision were is the optime point and were is, comparing to this point, the current process evolution point.

2.10 The process self-regulation function is a half-intern, half-extern function of the expert system, only for the close expert systems, it realize the reaction loop through which the image of a state process parameter, after its processing, is returned to the process under the form of a command for an actuation element which will maintain that parameter inside the normal, imposed functioning limits. The intern characteristic of the self-regulation function contains the routines which generates the exit variables in which are storage the numerical values of the parameters with a role in commanding the actuation elements for process regulation. The extern characteristic of the self-regulation function contains the entire assembly of digital-analogical converters and execution elements through which the expert system actuate directly, in the physical way on the process.

3. The software platform of the expert system

The software developing platform is formed by all the functions, methods and procedures which concur, through there hardware components, at the supervision and control of the process. The software platform is an application of a machine program dedicated to the process for which it has been written. The application (or the package of applications) is necessary to be developed under a very flexible programming medium, which can give the user, through the program, the possibility to modify, develop, eliminate, add, or ameliorate the

procedures and functions written for the management of the process. In the case of complex processes, which have a fast evolution in time and on many simultaneous sub-processes, applications which are rolling multi-tasking are needed, so that, all the sub-processes of the base process can be monitorised at the same time. Because the graphic representations are more easily and fast interpretable by the human operator, the software developing platform of the system will have to be based on an advance graphic support, which can be easily adapted to the needs.

Other important characteristic which is bound to the programming platform on which the expert system is build is the realization of redundancy between the functions of the work stations on one side and between the functions of the servers on the other side. A redundant system supposes that in case equipment is damage, or has a certain problem, another equipment of the system can temporally take its place into the process, until the reparation of the problem. The redundancy is not a vital characteristic at all the expert system, but its realization leads at an increase functioning security.

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