Extending the applied software in the contemporary thermal power plants for increasing the intelligence of the automatic control system

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Abstract. During the last decades, there can be noticed an increase of interest concerning various aspects of intellectual diagnostics and management in thermal power engineering according the hybrid principle. It is conditioned by the fact that conservative static methods does not allow to reflect the actual power installation state adequately. In order to improve the diagnostics quality, we use various fuzzy systems apparatus. In this paper, we introduce the intellectual system, called SKAIS, which is intended for quick and precise diagnostics of thermal power equipment. This system was developed as the result of the research carried out by specialists from National Research University “Moscow Power Engineering Institute” and Novosibirsk State University of Economics and Management. It drastically increases the level of intelligence of the automatic power plant control system.

1. Introduction
The progress of hardware, software and processor implementation of information processing intellectual algorithms is conditioned by their wide exploitation in various economical and technological systems during the last years [1]. Especially, it concerns technical diagnostics via fuzzy systems apparatus, in particular, fuzzy logic, fuzzy sets, neural nets, genetic algorithms, associative memory, expert and some other intellectual and hybrid systems which have not been used earlier in industry, national economy and power engineering in Russia [2]. Almost all special tasks, which may be solved via such intellectual systems, are reduced to the following strategic problems, including those of state importance [3].

(i) Trouble-free, reliable, safe and efficient energy production at the thermal and nuclear power plants; providing ecological clearance during the national life support.
(ii) Increase of the service period and the level of reliability of the main and auxiliary industrial and power equipment.
(iii) Intensive exploitation of automatic working places with an intuitive user interface which allows to control the equipment and make the working process in industrial and power plants much safer; such automation is able to provide technological protection and block commutation installations.
(iv) Increase of the economical efficiency of power plants by means of using actual state diagnostics instead of planned and precautionary one.

(v) Improving the quality of decision-making in the sphere of power engineering.

The mentioned approach allows to consider the defect (existing or developing) or the accident as a precession causing the change in the state of the mechanism. The physical process recognized by the actual mechanism state becomes clear. As the result, along with revealing the separate problems and defects we are able to study their reasons too. Such approach substantially widens the volume of knowledge and information accessible to the personnel who are able to learn more about the possibilities and limitation of the equipment and, thereby, increase the service period albeit in a soft mode (if is is required). Using the methods of recognition, evaluation and recovering, we developed an effective modelling methodology and implemented it in the software environment called SKAIS — the system of control, analysis and tracing the power installation state. SKAIS utilizes both exact and fuzzy knowledge in order to evaluate the technical state of the power installation and switch it into the soft mode, i.e. maintenance according to the actual state [2, 3]. The ultimate goal is to solve equation which encompasses the relations of the system as a whole.

In order to prevent the failure, the new methodology allows to identify the states of the equipment using not only the exact knowledge, but also using the fuzzy knowledge. At that, the mechanism is considered as an object of exploitation and as an object of energy production. During the analysis, we concentrate at a certain part of the whole system and realize its optimization (we bring the object to the optimal state according to the goal function) by solving one of the two following tasks: the best choice among the possible states under the predefined limitations and the goal; the best choice of the direction, which determines the most efficient changes.

The first task corresponds to the static systems, while the second — to the dynamic or hybrid ones. The task of identifying the state of such complex mechanisms as power installations is multi-relational, multi-criterial and hybrid one. In this paper, we represent the power plants installations as systems having the following lifecycle: “the purpose of the mechanism — its

Figure 1. “Soft-regulation” conception for the power plant installation (considered as a hybrid system); system levels of the mechanism lifecycle and the procedure of working capacity changes.
exploitation according to the purpose — degradation — utilization” (see fig. 1).

These stages are especially descriptive for thermal power machines which perform a great volume of work adjoint with the risk while transforming the thermal energy into mechanic or electric energy. At the fig. 2 there is a conceptual scheme of SKAIS.

2. Description of the created information system
The functions of the created system are as follows.

(i) The initial information procession and discarding those figures which do not fit the required measurement interval (they are analyzed further).

(ii) Preparing and entering source data arrays (represented as vectors) in order to fulfill the assigned tasks, including the diagnostics and information channel control.

(iii) Adjusting the system according to the assigned task by entering the matrix with the model features.

(iv) Processing the information obtained during the express-tests at the power installation.

Figure 2. SKAIS subsystem for diagnostics of technical state in the power plant control contour.
In reality, we need to proceed heterogeneous and different information in order to evaluate equipment readiness, analyze its failures, extend the service period etc. Moreover, much of this information is of bad quality (ambiguous, loosely defined, fuzzy) and the quality may differ depending on the case. This problem may be conditioned by various estimation errors intrinsic for the big aggregates.

The system database consists of two types of data: constant and operational. This data is gathered both from issued detectors and using additional measurement and control devices, which are targeted at the following features.

(i) **Constant data** (which includes mathematical equation coefficients, empirical constants, nominal values of technological parameters etc.) is stored in the separate database arrays.

(ii) **Operational data** is gathered during the mode experiments and can be entered either manually or automatically.

(iii) **Software application** pack the processed data into special arrays making it available for operators requests according to the assigned tasks. Every array is represented as five-columns matrix, where the number of row does not exceed 50; the last 10 rows correspond to the technological mode features, such as the oil quality, the air temperature, the air expenditure, the rotation frequency etc.

(iv) **Features and their quantity** may be altered by the operator according to the type and state of the aggregate, technological scheme and the assigned tasks.

(v) **Technological parameters** include such indicators as generator terminals power, fuel expenditure, pressure, vibral shift of the rotor, noise, temperature etc. Their number is also may be altered by the operator.

(vi) **Results of the tasks solution** are formed into separate tables via special software and are accessible through a menu according to a corresponding key; it is possible to vary the initial feature matrixes and to trace the solution process; some results can be stored in the database for a long time at the hard memory disks. When entering the data manually, the results are obtained immediately.

(vii) **Structure of the database** reflects the structure of the data about the various-complexity equipment state along with records and fields names. The data is described and manipulated with the help of a specially developed language. The requests are also written in this language with injection of the terms adopted by the data model. The records are created by SKAIS on-the-fly, i.e. at the moment when they are requested or formed in application program. In order to create records in the model, the database management system keeps information about how do records and their fields are formed from physical database data. This information is defined via a special mapping between physical and model databases. Thus, the database management system plays a role of direct and inverse mapping between these two databases. The mapping description above the correspondence information contains also other necessary metadata about the stored data such as their code, order, indexes, position, relations, methods for access etc. However, some tasks are assigned to the operation system of the computer.

(viii) **The specially created one-piece database** confines all the programs and software of the dialog environment. At the figures 3, 4 there are depicted some examples of how does SKAIS proceed underpressure parameters in the vacuum space the turbo-aggregate T-100-130TMZ for different power indications and the state parameters.

3. Conclusion

Our results demonstrate that employing the fuzzy information allows to improve the quality of the models used for identification, forecasting, decision-making and optimization while power
Figure 3. Parameters estimation using SKAIS (example 1).
installations diagnostics and management. It creates some sort of intellectual (expert) diagnostic environment and provides us with models which are able to represent the actual installation state adequately. This model is intended to be embedded into the control circuit of the thermal power plant. Exploitation of such intellectual environment leads to increase of the equipment efficiency and its service period. The equipment becomes more reliable because the intelligent system is able to reveal errors quickly and, as the result, prevent the failures and denials [4]–[7].

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