

ENSURING THE EFFICIENCY OF DECISIONS, MADE BY POWER UNIT OPERATORS AT THERMAL POWER PLANTS AS A MAJOR FACTOR FOR THEIR SUSTAINABLE CONTROL

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Abstract: This paper deals with the development of a list of key measures to reduce the impact of factors of the external and internal environment on the decisions made by power unit operators at thermal power plants, and the sustainable control of the power units. The measures given will enable rational decisions to be made by the operators intensively working in stressful conditions. According to the target task concerning research into the object's state, it is necessary to form a model of the dynamic situations for each aggregate and energy-active object in the state area, and to project them into their target area at each level of the hierarchy of a thermal power plant's technological system, linking by interface the databases, information and measurement systems of selecting the operations data, knowledge bases, expert systems and CAD systems of the upper level with operational and administrative staff.

Key words: power unit, management system, automatic control system.

1. Introduction

In the current economic conditions, management of thermal power plants requires clear and coordinated actions at all its levels. It is aimed at making optimal use of manpower, material, financial and other resources to provide high quality and uninterrupted generation of electricity. A hierarchical structure of thermal power plants is diverse and multi-layered in terms of dynamics of the physical and chemical transformations of the resource flows in the power units' boilers, i.e. burning of coal dust in a stream of the hot air in the boiler, heat-exchange processes for warming water, and its transformation into high-energy steam of high pressure, converting the thermal energy of the steam into the movement of a turbine, which is coupled to a generator of electricity, converting the flows of electrical energy and their redistribution in high-voltage distribution networks, which in turn requires, to tackle the tasks of effective management of thermal power plants, the staff to possess professional skills and knowledge, modern system analysis and information technologies, a capability of integrating into man-machine control systems, an ability of making decisions in boundary modes and extreme situations on the basis of the expert's knowledge.

The two main levels of hierarchy can be distinguished as to the management of thermal power plants: centralized control of the plant as a whole and all the processes occurring all over it, and control of individual units. A particular attention, in our opinion, should be paid to the ensuring of the efficient performance of the main group of the personnel who are involved in the important processes of power generation. Among the activities that can promote the optimal performance of the staff can be considered the measures directed towards the development of the staff, establishment of effective communication at thermal power plants, creation of a strong and positive corporate culture, etc. The main groups of workers that should undergo such measures are: heads of energy companies and enterprises, their deputies responsible for industrial activity and labor protection; managers and specialists of production departments at energy companies, power plants, electrical and heating networks; managers of laboratories intended for testing and control; managers and their deputies at operations control centers; operators at all managerial levels; instructors at in-companies training centers; production supervisors at power plants, electrical and heating networks; thermal power plants shift supervisors; shift supervisors of individual departments; leading power unit maintenance engineers, etc. However, the actions of the employees involved in the supervisory control of the power units at thermal power plants are crucial for the uninterrupted electricity generation. Making managerial decisions regarding a mode of power unit operation is characterized by high intellectual and psychological load often resulting in stresses, and consequently, a reduction in the power unit control efficiency. The aim of this paper is to develop a list of key measures to reduce the impact of factors of external and internal environment on making decisions by power unit operators at thermal power plants and on the sustainable control of the power units.

2. Statement of the problem

The qualitative solution of the problem related to the sustainable management of power units requires comprehensive knowledge of the model and dynamics of the object's behavior, the procedures of synthesis of

targeted management strategies and their correction in case there is a change of the situation caused by some threats. Therefore, an important issue in the system of power units control is to study all aspects of power units functioning (structural organization, energy flow dynamics, management under normal and boundary conditions). Besides, the application of the obtained results can be possible if there is a structured knowledge of modes of operation, normative data, dynamics of the thermal power plant (TPP) structure of management, as well as availability of intellectual decision-making support systems.

The analysis of the structure of the power unit control systems in a boundary mode confirms the need for a purposeful simulation of the boundary modes, forecast of situation dynamics, and training of operations staff in order to develop decision-making support systems for the improvement of management efficiency. This will ensure a quick response of the staff to emergencies, distracting circumstances, increase the level of stress resistance, and all production process participants' confidence in their actions. Therefore, the task of creating the decision-making support systems and their engineering contents based on logical-and-mathematical representations of knowledge is an urgent scientific issue.

The state of research in the analysis and synthesis of robust control systems in the high-tech industries is at a high level, but the methods used turned out not to allow the problem of stability in conditions of strong perturbations of information and power structure of the object under control to be solved. The classical methods for modeling of the control systems through the use of differential equations to describe their dynamics are not functionally and structurally complete, because they do not reflect the information and energy structure of the technological object. That is why the procedures of solving the synthesis tasks need to be complemented by introducing models of targeted structures and conjugated with them targeted areas, models of perturbation sources, models of information-energy interactions when selecting the information, models of selection algorithms, detection and processing signals concerning the state of the object that is the basis for the formation of targeted decision-making. The procedure of the synthesis of robust automatic control systems is based on matching between the problematic target tasks and the class of standard control systems with some degree of adequacy of modeling and synthesis of automatic control systems.

To ensure the robustness of the control systems, it was proposed to use a system hierarchy for describing the levels of a technological system model: a linguistic description of the object model; set-theoretic mapping of the structure and dynamics of the technological systems;

logical-and- mathematical models of control processes, and models of reflections of situations that have become the basis for creating the systems of automatic technological process control using the concept of information resources and utilizing information technologies in management. [1]

3. The problem solution

In terms of information technologies, we can distinguish the following hierarchy levels of the technological system shown in Fig. 1:

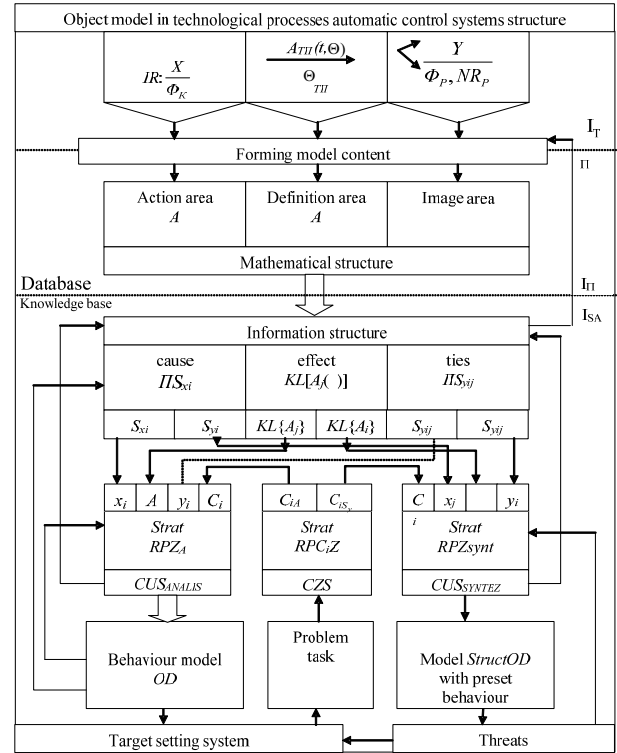


Fig. 1. A logical structure of the process of solving a strategies synthesis problem.

- level I_{TI} – the technological process in which exchange and transformation of material and energy resources take place;

- level I_{SA} – the information infrastructure (IIS – object states area, $KL[A_j]$ – the class of converting operators, $KL [Strat RCZ]$ – the class of problematic task solving strategies, $KL [Strat RCZ]$ – the class of targeted task solving strategies, $KL [Strat RPZsyntezu]$ – the class of synthesis strategies).

The first level of forming intellectual transformation is a shift from models of dynamics with a given mathematical structure to information structures in representing classes of models. This approach to the choice of synthesis procedures requires creating basic models of trajectories that describe the acceptable behavior of a system based on the selected strategies of achieving goals. [6]

A flowchart of the situational-game model of automatic control systems of the technological processes is shown in Fig. 1, and it consists of:

- KBZ – a conceptual knowledge base of the structure and dynamics of the transformation of energy-intensive resources;
- CUCRPZ - a targeted system that sets the goals and methods of solving problematic control tasks;
- CUCTII – a model of the targeted control system of a technological process of energy flows formation and transformation;
- FODdsyt IISSu – a shaper of a dynamic situation image in the area of the status of the energy-active object control system;
- TP-ACS – a model of the technological process control system, comprising a source of global and local resources – GIRE, IRm, IRme; sources of perturbations – IVF, a technological process reactor model – MR [TII], an observer – IC BD(NS), a target-oriented control system.

As we can see in Fig. 1, building the strategies for solving the problematic tasks requires the experts' participation, who would, based on their experience and knowledge, coordinate the choice of optimal management strategies in technological processes automatic control systems, using theoretical knowledge and knowledge accumulated during the operation of thermal power plants.

According to the the purpose of the article, it is necessary to minimize the impact of various factors on decisions made by a power unit operator. To do so, we should define procedures and means of selecting the data on the status of technological objects and environment of power-active structures.

Fig. 2 shows a model of selecting the algorithms of streaming data processing and the recognition of situation images for decision making. [7] The diagram of the processing procedure involves the study of:

- a targeted task model of technological data processing;
- a system of local and global management purposes;
- a system of strategies to achieve the goals as a basis of forming decision-making procedures concerning the management of units under control;
- a model of the target area, states area, a metric scales model for assessing the degree of movement trajectories closeness in the status area;
- a model of the object under control, sources of resources, types of sensors for observing and implementing the mechanisms for supplying resources;
- a system of sensors and measurement converters in the information system.

Thus the process of selection and processing of data should be oriented towards the target task and strategy of its solution in order to adequately reflect its condition in the system of goals, identify the extent of its approximation to the boundary mode and its origin in the target area. [2]

According to the target task concerning the object condition monitoring, it is necessary to form models of the dynamic situations for each aggregate and energy-active object in the states area, and to project them into their target area of each level of the hierarchy of the thermal power plant technological system, linking by interface the databases, information and measurement systems of data selecting, knowledge bases, expert systems and CAD systems of the upper level with operational and administrative staff [3] (Fig. 2).

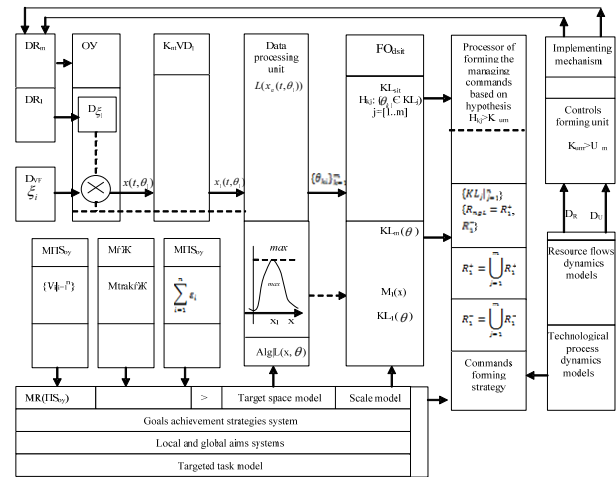


Fig. 2. Model of choosing a structure of data processing algorithms for making managerial decisions.

Such a structure of managerial information preparation includes:

- a unit of intellectual data analysis;
- a unit of operational object data storage;
- an expert system and (DMSS) decision-making support system with a DM (a decision-maker);
- an object with information-measuring system;
- a multimedia system for displaying the dynamic situations.

The solution of the problem concerning the synthesis of robust management strategies is implemented by technological structures on the basis of information and resource concepts, heuristic, gaming and axiomatic methods. With this approach being involved, the implicitly given strategy of perturbation compensation for maintaining the state of equilibrium by the balance of resources, based on the concept of the target area, expands to a target decision-making strategy according to the recognition of dynamic situation images in the system of states, their classification according to the

standard classes of alternative situations and to taking managerial measures to achieve the goal.

The synthesis of behavioral strategies and diagnostics of power system state is based upon basic information and mathematical models that should be oriented-arranged and stored in the knowledge bases, and made accessible both to operators and experts.

On conditions that there is a stable electricity grid load, within the unit capability standards, denormalization is only possible due to destabilizing constructive factors (failure of units). In case of changes in the generators load, failures in the supply of fuel resources through the preparation system into the boiler, changes of the atmosphere dynamics (pressure, wind speed), stability of energy generation modes is disturbed. Therefore in the context of the situation, it is necessary to make co-ordinating decisions on the control of all aggregates of the power unit on the basis of situation assessment formed by data blocks received during the continuous measurement of parameters of all the aggregates, taking into account the impact factors and their causal relationships.

Assessments of the situation are reflected in the state and target areas through the images on the cycle of the terminal time needed for making managerial decisions. Accordingly an automatic control system operator must understand a situation in the dynamics of the power unit, determine the tendency in the state change, and decide whether to make a coordinating decision.

In case of a dynamic mode change from a minimum load to the emergency, it is necessary to foresee proper strategies of going out of the crisis which are built relying on the likely trajectory of the power units into the emergency area of the normal and crisis load of the power units.

4. Conclusion

Thus, having analyzed the logical structure of the procedures of synthesis of management strategies of automatic technological process control systems and the operator's behavior under ultimate load of the unit boiler, it can be stated that an important task when analyzing data streams is to build effective means of mapping the situation, and to assess their content at a given time, and investigate causal relationships according to the data interpretation. These measures will contribute to the improvement in rational decision-making by the operators working in the conditions of high intensity and stress.

To solve the problem of stabilization of power unit modes, it is necessary to build an information-resource model of the objects to control the aggregates, of both main and auxiliary to supply fuel, water, and air. It is necessary to identify all causal relationships of the negative factor influence and components of the dynamic structure of the controlled object modes at all

levels of the hierarchy and to adjust the parameters of the dynamics of all parts of the power unit.

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ЗАБЕЗПЕЧЕННЯ ЕФЕКТИВНОСТІ ПРИЙНЯТТЯ РІШЕНЬ ОПЕРАТОРАМИ ЕНЕРГОБЛОКІВ ТЕПЛОВИХ ЕЛЕКТРОСТАНЦІЙ ЯК ОСНОВНИЙ ФАКТОР СТІЙКОГО УПРАВЛІННЯ ЕНЕРГОБЛОКАМИ

Андріан Нога

Описано розвиток ключових заходів щодо зниження впливу факторів зовнішнього та внутрішнього середовища на процес прийняття рішень операторів енергоблоків на теплових електростанціях і на стійке управління енергоблоками.



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