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COMPLEX ANALYSIS OF PLANNING THE POWER STATION EQUIPMENT REPAIR IN GENERATING COMPANIES

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The problem of planning the thermal power station equipment repair in conditions of transition to adjustable markets of energy has been analyzed. The bases of applying the system approach in conditions of real restrictions by financial resources are stated. The method based on classification of sources of repair work initiation and considering priorities of works for different control levels is offered as a scheduling algorithm.

The process of action on the system for its regulation, improvement and development is understood under the control in a general sense. In power engineering two types of control processes: on the one side, it is a purposeful action on engineering processes and on the other side – on groups of people – management may be distinguished. The first type of control has only a technical aspect – physicotechnical bases of power engineering and the majority of processes are well studied in this field. Acquirement of the main laws of engineering processes in power engineering allows applying successfully mathematical modeling [1, 2] and optimization algorithms for selecting parameters and modes of complex engineering systems.

The second type of control has been considerably complicated recently [3, 4]. The reason is the market relations forming in this economy sector. Economic management conditions for power engineering enterprises varied significantly. One of the aspects of this complication is a double position of power engineering industry (and each enterprise) on the resource market: on the one hand, fuel and physical resources are acquired by market prices, on the other hand, prices for power engineering product in the form of electro- and heat power is controlled by state authority [5].

The function of economic control process is to support a balance between revenue and cost-based parts of generating company. Moreover, total costs for the equipment maintenance and repair are connected with each link of repair branch organization. Therefore, when planning repair the annual control of financial resources for their implementation is of great importance. Costs for repairing are crucially necessary as the repairing domain allows not only maintaining the main equipment (boilers, turbines and generators) up to the mark but predetermining correct and efficient operation of all supplementary and supporting systems.

Certain stages of lifecycle are typical for the majority of power plant equipment units as well as for buildings and constructions (Fig. 1).

As it is seen the repair necessity follows from the fact that processing equipment is worn out, the characteristics of its elements and constructions change that finally results in decrease of capacity, degradation of power station performance. In order to compensate the consequences of these, generally negative, processes the organization using the equipment maintenances regularly its specification, such as: maintenance, repair and technical diagnosis. And, in comparison with other industrial productions power equipment is worn out both at operation and at downtime. Therefore, the repair volume is determined not only on the basis of «uptime» but also subject to the influence of many other factors. In particular, concrete configuration, the main manufacturing principles, possible consequences of repair unavailability in set time should be taken into consideration.

Fig. 1. *Stages of the equipment unit lifecycle*

Обоснование – Validation; Проектирование – Design; Строительство – Construction; Пуск – Start; Эксплуатация – Operation; Техническое обслуживание – Maintenance; Диагностика – Diagnostics; Ремонт – Repair; Реконструкция – Reconstruction; Модернизация – Modernization; Вывод из эксплуатации – Decommissioning

From organizational point of view the repair at thermal station may be presented as a sequence of certain procedures (processes), Fig. 2, which are carried out by each type of repairing. Each process is regulated by normative documents both to the extent concerning its occurrence and planning and to the extent concerning its implementation, and has its risks and external factors preventing its completion. Estimating the stage significance it should be taken into consideration that solution on repairing is practically impossible to be changed after completion of the process 4 («Purchase»). Therefore, the main stages which define the necessity and possibility of repairing are the processes 1, 2 and 3 («Initiation», «Planning» and «Approval»).

When repairing, various resources: staff both specially trained and unskilled, machines and mechanisms,

materials and reserve parts, finance are used. Alongside with this fact the success and efficiency of repairing depends greatly on adjacent processes connecting with repairing: material and reserve parts delivery, staff management, engineering data file etc. A great number of various structural subdivisions, responsible people, contracting agencies take participate in repair activities. They all have one final objective – to provide operating availability and good order of equipment, buildings and constructions.

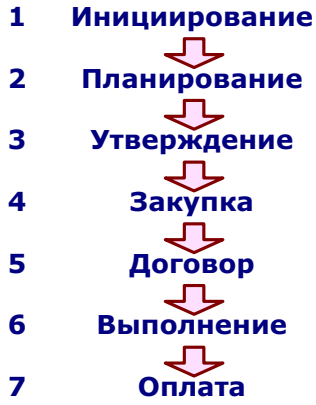

Fig. 2. *Processes (engineering-organizing stages) of repairing*

Инициирование – Initiation; Планирование – Planning; Утверждение – Approval; Закупка – Purchase; Договор – Agreement; Выполнение – Fulfillment; Оплата – Payment

Each repair work has certain characteristics (cost, labor intensity, working hours) and the set of works accepted for implementation is limited by budget appropriated for their performance and time (starting data and performance period).

Thus, a choice of repairing work set in each concrete case is the task solving which many factors should be taken into account. The consequences, interconnection and interdependence both repaired parts, elements and diagrams and techniques in whole should be also taken into consideration. Solution of such difficult-to-formalized problem is the problem which should not be considered within the limits of traditional (trivial) approaches.

In order to solve this task correctly the above-listed factors should be coordinated together and repair works should be selected for performance with obtaining maximum efficiency in their completion. The method which is used for solving the problem should be available and admissible for any management level, besides, the method should include a possibility of coordinated estimation of repair works at different management level. It may be fulfilled on the basis of system approach which allows on the one hand taking into account the determinative engineering principles of manufacturing processes in power engineering and on the other hand predicting correctly the consequences of under-repair and as a result, probable under-supply of electric energy in power system.

Use of analytical approaches at repairing allows solving such problems with acceptable efficiency:

- perspective object planning of repairing;
- annual planning of repairing and budget;
- annual planning of repairing volumes, physical resources delivery;
- detailed planning of physical and human resources;
- account of resources for off-schedule and emergency repair;
- estimation of financial and physical resources for potential off-schedule works;
- design of minimum substantiated value of the equipment reservation.

Application of the system approach assumes the presentation of the described problem in the form of interrelated hierarchy of simpler problems.

The simplified repair control diagram of such kind is introduced in Fig. 3. One can see that relations influencing the making of decisions determining the required and possible volume of repair works have both series and parallel character. The general hierarchical diagram of the repairing processes is introduced in Fig. 4.

Determination and selection of works for manufacturing is the procedure which is carried out by the same scenario, uniformly, however, the concrete conditions which should be taken into account change. For example, when determining the characteristics of repairing a pump, boiler unit or another equipment there is a following procedure: the required volume of work, cost of maintenance for its fulfillment, amount and cost of necessary material resources are defined. In this case: operating time from the time of the last repair, failures, possible consequences of the failure, management directive demands in turnaround time, estimation of node influence on reliability of the device or the station as a whole should be taken into account. The conditions which can change the repair work characteristics are the year period, fixed load, climatic features, skilled service personnel etc.

Therefore, as a rule, selection of repair works is examined and carried out as a set of processes of making statistic decisions at adaptation, i.e. decision feedback. In other words, a successive question is considered subject to the conclusions at examining the previous stage of analysis [3, 6]. At the same time the decision-making is rather subjective process that may result at the same conditions in different conclusions of various specialists. In order to minimize the differences in determining this or that repair work and decrease maximum the disagreement in procedures of matching the works (such matching is carried out in various engineering departments and company structural subdivisions) the system of objects and conditions admitted for examination is required. This system should include a rather simple technique of selecting works. Such technique should give the results which are available and comprehensible by selection logic for each level of repair management in the company.

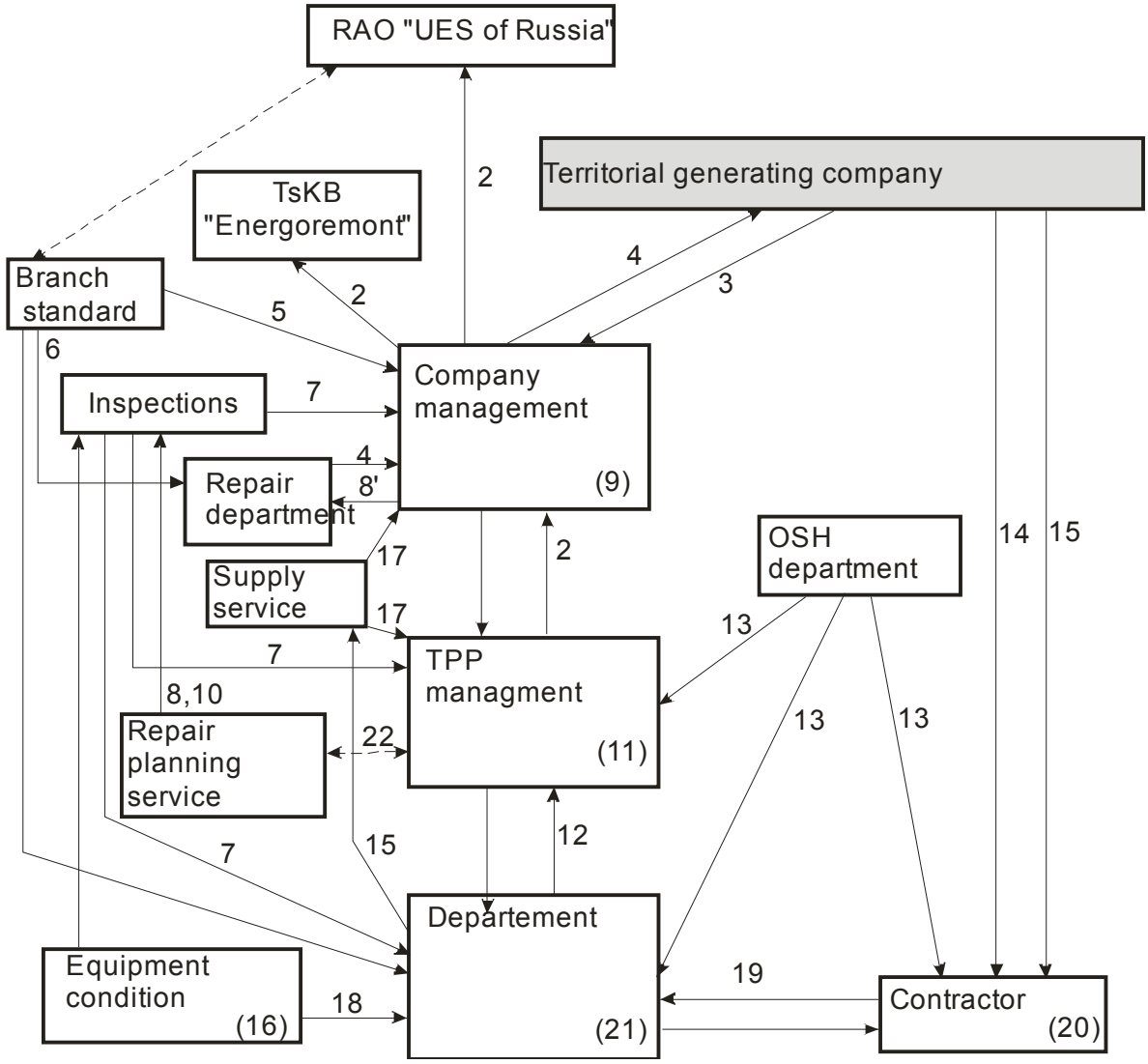

Fig. 3. *The diagram of repair management: 1) directive documents (orders, directions); 2) concordance of repair volumes, time; 3) directive documents (orders, directions), financial plan, budget; 4) purchase delivery; 5) requirements; 6) frequency, volume of repairing; 7) regulations; 8) TETs schedule ; 8') company schedule in whole; 9) plan approval; 10) engineering task for purchasing; 11) work planning; 12) work validation; 13) control of SE rules observance; 14) agreement; 15) computation; 16) diagnostics, defect book, failures; 17) cost of inventory holdings; 18) repair frequency, volume; 19) performance; 20) work implementation; 21) work occurrence; 22) adjustment*

One of preconditions for constructing such system consists in the fact that the objects as separate units are well described and regulated in details. The equipment with technical characteristics, interrepair times, volumes of repairing and maintenance, the designed and rated inputs of labor resources, the required nomenclature and amount of physical resources, limitations on repairing period and financial resources, the process of the determined and approved repairing and maintenance itself may be referred to such objects [6].

The complexity of constructing the system consists in ***development of integrated selection criteria*** for carrying out the works at the fixed time period and ***the selection procedure itself***. The repair works represent a great number of various process flows of manufacturing different in cost and elements. They are different in degree of influence on reliability, efficiency, volume of productive capacity etc.; but the most important thing is that they have different degree of importance although they are combined into one cost item by the business plan.

Reliability, efficiency and ecological compatibility of power manufacturing depends directly on the state of the enterprise capital assets [4] and the labor consumption standards of each operation and the required physical resources were developed for their maximum providing [6]. Standards and proper demands were developed in conditions of the plan economy; it is impossible currently to follow all the demands of those standards at repairing. The valid planning technique – budgeting imposes a condition for unconditional fulfillment at all management levels the limitation of repairing budget for each concrete time period [4, 6].

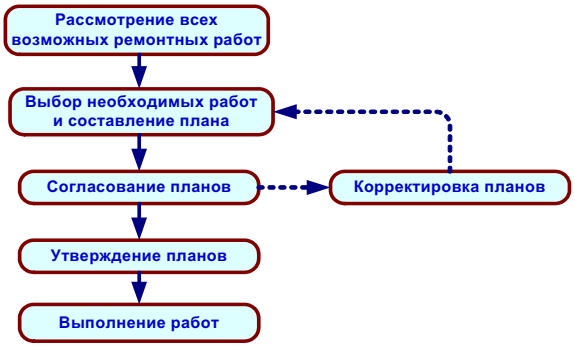

Fig. 4. *The generalized diagram of repairing planning processes*

Рассмотрение всех возможных ремонтных работ – Examination of all possible repair works; Выбор необходимых работ и составление плана – Selection of necessary works and planning; Согласование планов – Plan matching; Корректировка планов – Plan correction; Утверждение планов – Plan confirmation; Выполнение работ – Fulfillment of works

Other typical features of control systems in power engineering at the present stages:

- relative complexity of the system itself and control functions;
- amplification of demand of repair production rapid adaptation subject to increasing control centralization;
- growing information overloading of the control system;
- the occurred contradiction between the process requirements to the modern manufacturing processes and low level of mechanization and automation of administrative work virtually existing should be also taken into account.

The designated problems concern, certainly, any problems of planning in power engineering. Our attention is concentrated on one of the most important problems: the way of selecting those repair works that should be carried out within the frames of financing from the whole repair works required for fulfillment.

The methods of network simulation are usually called the tools for controlling repairs in power engineering [7]. Repairing at power plants represents a complex and important task combining all nodes and elements of the device, securing, providing physical and energy resources, recording work of each team which fulfill thousands of various operations. The network simulation was carried out for controlling such processes [8]. However, this system gives the «formula» to the question «how to do?», i.e. it is jointed to the control process when they have already determined and selected «what to do».

Currently there are many information systems and bundled software in the world intended for solving the planning problems, controlling the fixed assets, resources. They were all developed for implementation of enterprise management strategy – MRP, ERP, CSRP etc. Inner filling of these systems is intended for answering the question «how to manage better?» but it does not give the model of choice «what to do in the whole volume of works if there is not enough finance for its complete fulfillment?».

The algorithm of sequential comparison of repair work characteristics and further construction of financial priority-oriented diagram of the design of planning the repairing of equipment, buildings and power-plant constructions is suggested as a solution of the stated problem within the frames of this article. In order to implement such approach all repairing works are considered as the objects with the same characteristics; in this case they may be described as a homogeneous set. The initial determination of work initiation sources, then forming works with similar source (initiation) into groups for comparison by the importance, priorities and consequences is the joining base. Such groups are called the logic groups.

The analysis of long-term practice of forming repairing plans at power plants allowed forming the following logic groups of comparison: «instructions of oversight bodies and supervisory authorities», «the approved work schedule», «off-schedule repairs», «the safety regulation requirements», «the requirements of work mechanization regulations», «additional repair volumes», «service-utility repairing».

Firstly, all works determined and detected according to the existing technological normative documentation and operating condition are considered. The works conditioned by schedules, instructions, directive circulars connected with labor mechanization or content of production goods as well as works providing technical diagnosis, off-schedule and emergency works etc. are referred to them. They all are taken into account and compared for selecting and being included into one repairing plan for the planned calendar period.

A principle of the proposed algorithm consists in the following. All the works are compared relative to each other by the degree of importance, assigning priority: so the sequence of all works initiated for being fulfilled is formed. At present, however, there is no a unified criterion for estimating the priority of the whole list of these works. Therefore, till prioritizing all repair works are distributed by logic comparing groups. Then in each group the works are compared between each other with the assignment of priority numerical value of each work. Such distribution is introduced graphically in Fig. 5.

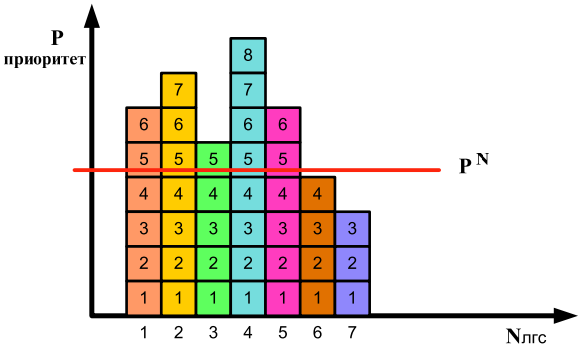

Fig. 5. *Diagram of logic groups of comparing repair works*

Приоритет – Priority

The volume of expenditures for carrying out works from 1 to ***P*** level where the volume of allotted budget is the boundary condition (P^N) is designed by the methods of discrete calculation. Thus, the system of determining repair works which may be fulfilled for the planned period is formed.

All the automated systems controlling maintenance and repairing proposed on the market and enterprise management standards on the basis of ERP-systems do not include problem solution set in this work as well as they do not consider this problem. Standards of ERP-systems (including CSRP, MES) solve the problems where the repair is considered as indivisible unit of purposes, tasks, resources and standards help the enterprise management to answer the question «what is the sum for repairing?». Modules of controlling maintenance and repairing included into many corporation information control systems automate the processes of repairing organization and fulfillment and help not only to carry out the repair work but to organize it more efficiently.

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«ENERGY SUPPLY» AND «ENERGY EFFICIENCY»: SPECIFICATION OF CONCEPTS, THE SYSTEM OF BALANCED PARAMETERS OF «ENERGY EFFICIENCY»

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On the basis of analysis of concepts «energy supply» and «energy efficiency» the inadmissibility of their identification has been shown. Parameters for quantitative characteristic of these concepts are specified. For the first time it is offered to use the system of balanced parameters of energy efficiency for developing norms of electric energy consumption.

In the papers devoted to the problem of efficiency of using energy resources, «at all stages of their life cycles» – from generation to consumption of end products (electric and thermal energy) – two concepts denoted by the terms «energy saving» and «energy efficiency» are used [1]. However, there is a great difference of these terms among the specialists; therefore, in some articles they are used as the same and in others the term «energy saving» is rejected. The supporters of the second position suppose that energy should be consumed in volumes required for implementation of your demands, i.e. not to save but to use it efficiently and on this basis, identifying these two terms they propose to exchange the term «energy saving» by the term «energy efficiency». It is supposed that such difference occurred as a result of the fact that a serious uncertainty was admitted at interpretation of the term «energy efficiency» in the Law of the RF «On energy saving» [1]. The following explanation of these two key concepts:

- «energy saving» is the implementation of legal, scientific, engineering and economic steps directed to the efficient use of energy resources and involvement of the secondary or renewable energy resources into economic circulation.
- «energy efficiency» is the achievement of engineering capabilities and economically justified efficiency of using energy resources at the existing level of development of technology is given in the Law.

It is not difficult to see that «implementation» in the first explanation and «achievement» in the second one mean the same thing; a certain complex of actions (measures) directed to increase of quality (efficiency) of consuming energy resources. Such understanding of the first term is not objected. As for the second one, it should be taken into account that the term «efficiency» in all spheres of human activity is used for defining the achieved quality (efficiency) of realizing the aimed actions and engineering processes. In concrete cases the