

## The operational reliability of complex energy facilities

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### ABSTRACT

#### Keywords:

Diagnosis  
Prognosis  
Turbine  
Generator  
Compressor  
Defect

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#### Article history:

Received 19.09.2013  
Received in revised form  
18.11.2013  
Accepted 25.12.2013

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**Introduction.** The most effective methods to keep working of complex technical facilities, independently of the presence of these defects, are of technical diagnostics and forecasting.

**Materials and methods.** It was used diagnosis and prediction model, based on statistical data and analytical processes of change dependency properties of concrete materials. It was defined individual reliability indices based on technical parameters for each of them.

**Results and discussion.** Each company has its own individual combination of factors chaotically changing operational and reliability characteristics of the object and makes unpredictable chain of causality development of the same defect in the same objects. Account of individual reliability indices based on technical parameters in existing models diagnosing and forecasting and implementation of a comprehensive health evaluation facility will increase calculation occurrence of defects in the early stages of their development and improve the schematics for their prevention and elimination of each individual object.

**Conclusions.** Personalisation methods of technical diagnostics and technical forecasting can increase improve anticipation of defects in the early stages of their development and allow better decisions to eliminate them for each individual object.

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УДК 663.126

## Експлуатаційна надійність складних енергетичних об'єктів

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## Introduction

Complex technical and energy facilities, which depends on the efficiency of implementation of the most important and dangerous enterprise production functions used in any branch of human activity. Loss of efficiency of these facilities may entail large economic losses in addition to fires, explosions, contamination territory harmful substances, accidents with fatalities.

Complex energy and technology objects are usually designed for prolonged use, so they are subject to stringent requirements for reliability, according to which they must be in working condition only a certain period of time. Because of structural complexity of these objects, consisting of thousands of individual elements to support their continued operability pretty difficult. Furthermore these objects are usually operated by a designated period longer because due to their high cost they have a specific number of units of the consumer units. And the increase in the operational period in turn leads to an increase in the likelihood of the causes of major industrial accidents or disasters.

Complex technical and energy facilities usually are elements of the entire production system and have complex relationships with upstream and downstream of its levels, which also affect their performance.

Since these objects are mostly automated, we can not exclude the impact of their performance of the human factor. Decision to terminate the operation of complex technical and energy facilities to decommissioning or repair work is taken by the operator. This means that the timely termination of operation of the facility in order to prevent accidents it affects both the completeness and accuracy of the information about the state of the object components, and operational competence of the staff. Therefore, one of the most important ways to increase the reliability of complex technical and energy facilities are of technical diagnostics and forecasting , allowing to anticipate the problem and provide the most complete information exploiting the staff.

## Materials and methods

Modern systems of technical diagnostics and forecasting are narrowly focused or complex automated software and hardware, organizing science-based operation of complex technical and energy facilities in the face of uncertainty associated with limited information because of the large number of factors affecting their performance.

Evaluate the effectiveness of the forecasting process the following indicators: reliability prediction, forecast time algorithm implementations, the cost of implementing these algorithms , as well as the forecast cycle, which refers to the period of time for which the forecast has practical meaning. You can select the following cycles forecasting:

- period of obsolescence of equipment (industry level forecast);
- periods decision to stop, for transfer to the reserve and organization equipment repairs (planned, current);
- maintenance periods.

Evaluated the effectiveness of diagnosing the following indicators:

- the accuracy of the diagnosis, is a measure of certainty of decisions on the state of the object;
- volume diagnosis, which refers to a list of parameters to be monitored;
- completeness of diagnosis, characterizing the degree of coverage of all parameters;

- time of diagnosis, depth diagnosis, meaning the accuracy of determining the place of the defect;
- cost of diagnosis;
- degree of automation of the diagnosis.

Information received from the diagnostic systems, makes it possible to assess the actual state of a complex object and predict its possible changes. It is important to keep up with forecasts of information to a specific moment of the decision.

Today there are many software and hardware systems, which are based include the following diagnostic prediction model:

- model using the theory of similarity;
- probabilistic diagnostic models: diagnostic model of disorder, functioning model diagnostics tools based on usage modes;
- spending pattern of the resource;
- forecasting model equipment condition: analytical prediction model, probabilistic forecasting model, using classification methods for predicting the lifetime of the equipment.

All these models are based on statistical data, which are small and censored sampling and analytical processes of change dependency properties of specific materials (corrosion, wear, fatigue, fracture, etc.). Statistics provides summary data just about the most unreliable elements and nodes structure, while analytical ignore combination action of internal and external factors affecting the changes in the properties of materials. This means that these methods initially incorporated error, and it is impossible to put a fairly accurate diagnosis in determining and predicting performance of a specific object.

Virtually every complex technical and energy to work in special environments. Therefore, the definition of individual reliability indices based on technical parameters (design characteristics, forms of dynamics occurring in the object workflow, his regime parameters, characteristics of the working fluid, the selected configuration of the measurement and control process parameters, relationships with adjacent objects, etc.) for each of them will significantly reduce this uncertainty and increase the ability of these methods to anticipate trouble in the early stages of their development.

## **Results and discussion**

One example of a complex technical and energy facilities are refrigerator-compressor units, which are widely used in enterprises of meat and dairy and fish industries because of compliance technology cooling, freezing and storage of products and semi-finished products in these enterprises depends on presentation, quality and quantity losses during manufacture of the product itself, as well as the safety of the state depends on food stocks.

Compressor unit (compressor, built maslorazdelitel, oil cooler, oil pump, economizer control board) compresses a refrigerant and pumps it into the condenser. The controller displays the data from pressure sensors installed on the suction and discharge piping, performs management and regulatory capacity of the discharge piston lubrication system controls. Compressor units are equipped with shut off valves and check valves and suction and filter by suction. On the discharge pipeline built pilot pressure regulator that acts as a pressure control condensation in winter.

Same one of the most dangerous causes of failure of the compressor of the refrigeration unit is its operation mode to "wet steam". In this mode, the suction side of the compressor are not fed dry or superheated steam, and the steam vapor in the form of a mixture with

liquid droplets. Since the liquid has almost completely compressed, its presence can lead to water hammer in the compressor cylinder, and in the presence of erosion-corrosion wear or fatigue compressor—even to its depressurization and destruction. Level of material wear of the compressor is only an individual characteristic, due to differences in operating conditions. This means that the prediction of its performance shall be solely based on the results of technical diagnosis is considered compressor [1].

One of the conditions to ensure the smooth operation of refrigeration and compressor plants is a continuous supply of electricity, which in turn depends on the reliability of operation of generators. The main part of the electricity comes from heavy duty generators operating under variable load curve sharply modern power systems, so reliability indices for each of the power purely individual.

But since each company has its own, individual combination of factors affecting the performance parameters of the basic units and construction elements and chain development defects, and the chain of causality development of the same defect in the same objects can be changed.

By analyzing statistical data about failures identified the main components and design elements for each type of complex technical and energy facility, from which performance depends largely on performance of the entire object and which accounts for most of the defects, as well as the chain of causality development most defects.

The main components are generators rotor and stator cooling system performance depends on the following parameters: the current in the stator windings and rotor bars heating temperature, flow and temperature at the inlet and outlet of the supply unit, etc. Since interruptions in their work are not allowed to prevent sudden stops, they, like any complex technical and energy facilities are designed so that they are dominated by mostly developing defects, which are complex in their development and the flow time which is determined by the actual characteristics of the object and conditions of its exploitation.

Difficulties in the development of these defects is one defect that entails the emergence and development of another or several other defects due to many factors chaotically changing operational and reliability characteristics of the object and contributing unpredictable chain of development. Therefore anticipate defects in the early stages of their development and make the right decisions for their elimination is not possible without the use of technical diagnostics and forecasting.

Modern systems of technical diagnostics and forecasting is an automated software and hardware , allowing to organize evidence-based operation of complex technical and energy facilities in the face of uncertainty associated with limited information. Today there are software and hardware as "Neva-ASKDG" and "Vidas" allow generators anticipate defects in the early stages of their development and predict the development of adverse events over time.

But the above complexes provide diagnosis and prognosis of only vibration or thermal parameters, due to the fact that most of the defects is connected directly to the flow of these processes. But their combined effect on the object they allow more efficient use of power generators and significantly improve their operational reliability by reducing the amount of vibration and thermal defects during his direct exploitation through their prevention. The principle of prevention of the defect in all modern technical diagnosis and prediction based on a comparison of the diagnostic parameters obtained with the standard, they received the same time testing the technical documentation or the manufacturer, and the slightest discrepancy which, subject to approval, said of the birth defect. And as they predict the remaining time to failure of the object as a whole , taking into account the defect has arisen and, while maintaining the specified operating parameters.

But, according to [(6)] technical evaluation of generators using compartmentalized modern systems of technical diagnostics and prediction is not accurate. This is due to the fact that the construction of the standard by holding them the same tests and the determination of the technical state during operation of power generators can easily be mistaken in identifying the least weak node or element due to negligence and the undercount of all available at the time of inspection defects. Therefore, the evaluation should be comprehensive, and this requires preparation and accumulation of complete and accurate diagnostic information over a long period of its operation and increase the diagnostic procedures for the determination and prediction of technical condition of the power and determination of its actual residual life .

Developed and developing new methods of technical diagnostics and forecasting performance generators limited amount available to them because of diagnosed parameters reliability characteristics of the object itself, which clearly limit the number and location embedded in the structure. On this basis, for the implementation of more refined diagnostic procedures and systems of testing, with the primary information systems technical diagnostics and forecasting.

As a first approximation for the solution of prediction methods is desirable to use online analytical processing OLAP. However, it should be noted that the methodology OLAP operates averages and only allows you to check in advance formulated hypotheses . To build a comprehensive and , most importantly, an individual assessment of the forecast should use other technologies, such as one of the technologies Data Mining - Data-driven, to automatically build a model of behavior based on the information about the normal behavior of the system . Combination of developed and develop [2, 3, 4] allows us to find methods different sets of anomalies, since they have the following number of advantages:

- do not require a priori knowledge given about the system;
- allow you to set and monitor the relationship between the large number of parameters;
- capable of detecting the collective and contextual anomalies [1];
- able to process the data in real time and react very quickly to the appearance of anomalies, etc.

## **Conclusions**

Schematics for the prevention and elimination of defects in developing each individual object must be unique. And for this purpose with a view to making the right decision about when and how to address emerging defects must be a sufficient amount of information about the health of the objects themselves, which should provide a system of technical diagnostics and technical forecasting.

Personalisation methods of technical diagnostics and technical forecasting a specific object can significantly improve the diagnosis and prediction of performance of complex technical and energy facilities by preventing the emergence of defects in the early stages of their development. A cancer also allow better decisions to eliminate them for each individual object due to customize circuit solutions.

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