Peculiarities of diagnostics systems for electroenergetics facilities

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Abstract: Currently, the most important tasks of the electroenergetics are the implementation of operational and reliable diagnostic control of network elements, including the determination of electrical equipment operability. However, in many cases, due to the variety of causes of various faults and generally wide range of technical condition assessment, the results of such diagnostic control cannot be interpreted unambiguously, and these results are mainly expressed by high uncertainty in their content. For this reason, there is a need for effective methodological approaches that allow reliable interpretation of the obtained results of diagnostic control, which makes it necessary to clarify the main points associated with their selection and application. In connection with the above, the article considers some features of diagnostic systems, including faults of electrical equipment used in the electric power industry and factors affecting their detection, modern systems of technical condition assessment, as well as the justification of approaches that take into account the uncertainty of the data used during diagnostic control.

Key words: Electroenergetics, Electrical equipment, Diagnostic control, Diagnostic system, Uncertainty.

1. INTRODUCTİON

One of the priority tasks in the field of electric power systems is to ensure the operational capability of network elements, especially electrical equipment, within the framework of unit principles, as well as their control and maintenance through rapid and highly automated supervision, to regulate its operating modes. To address this issue, modern information and analytical systems should be integrated with program and hardware monitoring systems that allow for the collection of information about the object for subsequent processing, analysis, and management based on both traditional and high-quality new approaches. Given the diverse nature of information related to the operation of electrical equipment, including their possible uncertainties and unreliability, comprehensive approaches should be utilized for the establishment and analysis of diagnostic information systems.

Purpose Relevance of the problem and related research The development of the electric power industry aims to ensure high reliability and efficient management of power supply networks with various configurations. Solving these problems requires a certain energy information infrastructure, which includes programs and technical tools for monitoring, diagnosing, and analyzing information during the subsequent management of network elements and operating modes. The diversity of collected data necessitates the creation of specific mechanisms for processing, enabling the automatic or automated synthesis of diagnostic models in information and diagnostic systems and adapting energy equipment objects to operational conditions. Consequently, the article explores specific features of diagnostic systems for electroenergy objects.

Many scientific research works describe these features. Let's mention some of them. [1] shows that the development of power systems leads to increased complexity of their structure and demands on operational quality. It is essential to technically diagnose the current state of electrical equipment and ensure timely preventive maintenance. Currently, a technical diagnostic system that assesses the existing technical state of electrical equipment, ensures early detection of potential faults, and predicts their future development, has not yet been created. Therefore, there is a need to rely on heuristic approaches based on artificial intelligence methods such as artificial neural networks, non-linear pluralities theory, non-linear logic, and genetic algorithms. [2] notes that machine learning methods designed for binary classification can be used to solve diagnostic issues.

[3] examines the causes of technological disturbances in electrical systems, highlighting a range of characteristic conflicts in the protection and automation of power system elements, such as power transformers. Furthermore, based on examples of the use of non-linear logic and neural networks in various industrial sectors, [4] concludes on the appropriateness of using non-linear logic elements in the protection and automation devices of electroenergy networks. [5] discusses methods for modeling functional safety systems for electrical equipment, considering the uncertainty of initial data intervals. Through a comparison of efficiency indicators in various system variants, methods are developed for the optimal selection of safety systems for electrical equipment. [6] presents a new possible method for diagnosing the current technical condition of equipment based on non-linear expert evaluations and non-linear pluralities theory.

These studies demonstrate the complexity and diversity of issues related to the diagnostics of electroenergy objects and highlight the importance of developing advanced information and analytical systems for efficient management and maintenance of electrical systems.

Methods Factors affecting the reliability of electrical equipment and their determination

The evaluation of the technical condition of electrical equipment is the most important element of all major aspects of the operation of electrical substations and substations. One of its main tasks is to determine the usefulness or unreliability factor of the equipment during operation. It is generally accepted that if the condition of the equipment complies with all the requirements specified in normative documents, it is considered useful for operation; otherwise, it is deemed unreliable. The transition of the product from operational condition to unreliable condition occurs due to defects. The term "defect" is used to identify any individual malfunction of the equipment. Defects in the equipment can occur at various stages of its life cycle (manufacturing, installation, adjustment, operation, testing, repair) and lead to various consequences. There are quite a few types of defects. When identifying defects and making decisions regarding the subsequent operation of electrical equipment, it is important not to forget about the reliability and accuracy of the information obtained about the condition of the equipment. It should be noted that any diagnostic method of non-destructive testing does not guarantee full reliability in assessing the condition of the object. Errors are also included in measurement results, so there is always a possibility of obtaining incorrect inspection results:

- an object that is not faulty may be deemed useless (false defect or Type I error);
- a faulty object may be considered useful (undiscovered defect or Type II error). During non-destructive testing, errors lead to various consequences: Type I errors (false defects) only increase the volume of recovery operations, while Type II errors (undiscovered defects) lead to immediate damage to the equipment. It should be emphasized that for any type of non-destructive testing, it is possible to determine a number of factors that affect measurement results or data analysis. These factors can be conditionally divided into three main groups:

1. Environmental factors
2. Human factor
3. Technical aspect "Environmental factors" include factors such as weather conditions (temperature, humidity, cloudiness, wind strength, etc.) and time of day. As the "human factor," it is considered important that personnel have professional knowledge about the equipment and carry out inspections in a systematic manner. The "technical aspect" refers to the information database about the diagnosed equipment (material, passport data, year of manufacture, surface condition, etc.). Specific normative documents regulate the purpose of each type of non-destructive testing, the procedure for non-destructive testing, the tools used for non-destructive testing, the analysis of non-destructive testing results, possible defect types during non-destructive testing, and recommendations for their elimination.

About modern systems for assessing technical condition

The structure of all modern systems for assessing technical condition is generally similar and consists of four main components:

1. Data base (DB) - initial information for assessing the technical condition of equipment;
2. Knowledge base (KB) - a collection of structured rules in the form of expert knowledge, preserving all possible types of experience of experts;
3. Mathematical apparatus. It describes the mechanism of operation of the system for assessing the technical condition;
4. Results. Typically, this section consists of two subsections: the results of assessing the technical condition of the equipment and control measures based on the obtained assessments - recommendations for the subsequent operation of the assessed equipment. Both in guidance documents and other normative documents, various rules can be used as a knowledge base, including complex mathematical rules and functional dependencies. The results usually differ only in the "type" of assessing the technical condition (indices), possible comments on the classification of defects, and control measures.

However, the main difference between systems for assessing technical condition lies in the use of various mathematical apparatus (models), which primarily depend onthe reliability and correctness of the system itself and its operation as a whole. Despite all the advantages of existing systems for assessing technical condition, they have several significant conflicts in modern conditions:

- they are oriented towards solving specific problems for a specific owner (for specific schemes, specific equipment, etc.) and, as a rule, cannot be used without major modifications in other similar objects;
- they use data of various scales and different accuracies, which can lead to possible inaccuracies in assessment;
- they take into account the dynamics of changes in the assessment criteria for the technical condition of equipment, in other words, systems are not adaptable.

All of the above, in our opinion, deprives modern systems for assessing technical condition of universality, which is why the current situation in the electric power industry requires improvement or the search for new methods for modeling systems for assessing technical condition. Modern systems for assessing technical condition should be capable of analyzing data, searching for samples, forecasting, and ultimately possessing learning capabilities.

Artificial intelligence methods provide such opportunities. Today, the use of artificial intelligence methods is not only accepted in scientific research but also successfully implemented in various areas of life for technical objects.

Methods Possibilities of using non-probabilistic uncertainties in diagnostic systems of electric power engineering

The diagnostic system of complex electric power objects is multilevel with the following non-probabilistic information abundance:

1. point measurements and parameter values;
2. allowed intervals for their changes;
3. statistical laws of distribution based on individual characteristics;
4. linguistic criteria and constraints obtained from specialist-experts, etc. In a complex diagnostic system, the presence of various types of non-determinacies simultaneously necessitates the use of non-probabilistic uncertainties in decision- making,

which allows for adequate consideration of existing types of uncertainties. Accordingly, diagnostic characteristics, operating modes of electric networks, permissible areas, advantages of some diagnostic methods over others, decision-making risks, etc., should be converted into a unified format and presented as membership functions. This approach enables us to consolidate all available deterministic, statistical, linguistic, and interval-shaped information. Utilizing the possibility theory to deal with non-determinacies leads to the conclusion that, in fact, despite the non-deterministic nature, uncertainties are equated with randomness, whereas in many decision-making processes, non-determinacy's primary source is non-probabilistic uncertainty. Therefore, the selection of an adequate formal language is crucial, and thus, it is necessary to highlight the advantages of describing the decision-making process in a complex multi-level hierarchical system based on the theory of non-probabilistic uncertainties. This language allows us to reflect the essence of the decision-making process and the conditions of non-probabilistic uncertainties for a multi-level system, work with non-probabilistic constraints and objectives, as well as use linguistic variables to identify them. Monitoring and managing a complex system do not always require finding the optimal solution at any given moment because the costs of collecting information and significantly eliminating discrepancies (errors) in the system can outweigh the benefits obtained. Often, resolving a specific issue requires ensuring a certain level of non-determinacy.

The formulation of real problems by an individual entails some non-deterministic conditions and certain uncertainties in goals. While examining single-purpose systems, applying clear constraints and goals artificially allows us to obtain good deterministic models, for hierarchical systems, it is necessary to consider its relationship with all subsystems at all levels from a focal point of view. Considering the non-determinacy factor during problem-solving significantly changes decision-making methods. It is also possible to directly establish a non-probabilistic zone without directly considering the characteristics of non-deterministic parameters. In this case, a series of deterministic issues are resolved, and a collection of certain variants optimal for specific (or non-random) parameter values is obtained.

3.CONCLUSİON

The article analyzes specific features of diagnostic systems in the field of electric power engineering, considering the approach based on non-probabilistic uncertainties, including the evaluation of malfunctions of electrical equipment used in electric power engineering, factors influencing their determination, modern systems for assessing technical conditions, and the non-deterministic nature of the information used during diagnostic control.

REFERENCES

1.Dzh.S.Ah'yoev, Modeli i metody tekhnicheskoj diagnostiki elektrosetevogo oborudovaniya na osnove nechetkoj logiki. Dissertaciya na soiskanie kandidata tekhnicheskih nauk, Novosibirsk, 195 p, 2018.

2.V.N.Klyachkin, D.A.Zhukov, Prognozirovanie sostoyaniya tekhnicheskogo ob"ekta s rimeneniem metodov mashinnogo obucheniya, Programmnye produkty i sistemy, vol.32, № 2, pp.244-250, 2019.

3. G.N.Ansabekova, Vozmozhnosti primeneniya elementov nechetkoj logiki v ustrojstvah zashchity i avtomatiki elektroenergetichekih setej, The Scientific Heritage, № 80-1, pp.8-12, 2018.

4.O.N.Drobyazko, S.F.Nefyodov, Metody modelirovaniya i optimizacii sistem bezopasnosti elektroustanovok s uchetom interval'noj neopredelennosti iskhodnyh dannyh, Polzunovskij vestnik, № 4, pp.101-106, 2012.

5.S.Kokin, V.Manusov, J.Ahyoev, S.Dmitriev, A.Tavlintsev, M.Safaraliev, Diagnostics of the technical condition of electric network equipment based on fuzzy expert estimates, Energy Reports, vol. 6, Sup.9, pp.1383-1390, 2020.

6.V.Z.Manusov D.I.Kovalenko, Fuzzy mathematical models of transformer equipment diagnosis, Nauchnyie Problemyi Trans Sib Dalnego Vostoka, №2, pp.254-257, 2012.