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DIAGNOSTICS OF ELECTRICAL EQUIPMENT AT THERMAL PLANTS

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Abstract

Diagnostics of electrical equipment at thermal power plants plays a key role in ensuring reliable operation of power systems. This article examines methods and technologies for diagnosing electrical equipment at thermal power plants and their significance for ensuring the reliability of power systems. The work analyzes the main approaches to diagnostics, including non-destructive methods, equipment condition monitoring and the use of modern technical means, such as infrared thermography and ultrasound diagnostics. Particular attention is paid to the importance of these methods for ensuring the uninterrupted operation of thermal power systems and minimizing the likelihood of emergency situations, which is important for ensuring energy security and economic efficiency.

Keywords: infrared thermography, ultrasound diagnostics, thermal imagers, monitoring system, diagnostics

I. Introduction

Electrical equipment plays a key role in the operation of thermal power plants, providing power supply, process automation, safety and equipment control. It is used to supply electricity to all components of the installation, including security, control and monitoring systems. Automation of processes such as fuel regulation, temperature and pressure control is carried out using electrical systems. Electrical equipment also plays a role in ensuring plant safety through emergency shutdown, fire extinguishing and equipment condition monitoring systems [1]. In modern installations, energy-saving technologies and electrical-based energy management systems help reduce energy consumption and improve overall system efficiency. Thus, electrical equipment is an integral part of thermal power plants, ensuring their stable, safe and efficient operation.

Equipment failures in thermal power plants can have a serious impact on production processes and safety. Firstly, they can lead to a decrease in productivity or a complete shutdown of the installation, which in turn can cause losses in energy production and a decrease in the efficiency of the entire system. This can result in increased downtime, lost revenue, and increased equipment recovery costs.

The impact of equipment failures on safety is also extremely serious. Failures can disrupt the normal functioning of safety systems such as fire extinguishing systems, emergency lighting, gas leak prevention systems, etc. This creates potential dangers for workers, the environment and society as a whole. In some cases, equipment failures may be associated with emergency situations, such as accidents with the release of harmful substances or fires, which threaten not only the safety of personnel, but also the surrounding area and population.

Thus, equipment failures in thermal power plants have serious consequences for both production processes and safety, and require careful monitoring, maintenance and updating of equipment to prevent negative consequences [2-5].

II. Problem setting

Visual methods for checking equipment condition.

Visual methods for checking the condition of equipment play an important role in ensuring proper operation and process safety. These methods include visually inspecting the equipment for signs of wear, damage or other abnormalities, as well as assessing its environment. For example, engineers may check for cracks, corrosion, leaks, or other damage on the surface of equipment.

Another important visual method is to compare the current condition of the equipment with its standard or recommended condition. This may include comparison of indicators such as color, shape, size and position with specified standards or criteria for safety and effectiveness. For example, when visually inspecting a piping system, engineers can check for play, cracks, or leaks and compare them to the limits set for the system.

Visual methods may also involve the use of specialized equipment, such as infrared thermal cameras or ultrasonic flaw detectors, to detect potential problems that may not be visible during a normal visual inspection. These methods help to quickly identify possible malfunctions and prevent their development before serious problems or accidents occur.

Thus, visual methods for checking the condition of equipment play an important role in ensuring proper operation and process safety, allowing potential problems to be quickly identified and corrected before they lead to serious consequences.

Using Thermal Imaging Cameras to Detect Overheating.

Thermal imaging cameras are an effective tool for detecting overheating in a variety of systems and equipment, including thermal power plants. These cameras operate using infrared radiation, which allows them to visualize temperature differences on the surface of objects. Overheating can be an indicator of problems or malfunctions in the equipment, such as poor connections, overload, worn components or improper operation of the cooling system.

When using thermal imaging cameras, engineers can quickly scan equipment and identify areas of elevated temperature that may indicate problems. For example, overheating at electrical connections may indicate possible overloads or poor contacts, while overheating at the surface of pipes may indicate problems with the heat transfer or cooling system. With thermal imaging cameras, engineers can quickly identify potential problems, allowing them to take corrective action before serious damage or accidents occur.

Thus, the use of thermal imaging cameras to detect overheating is an effective method for diagnosing the condition of equipment in thermal power plants, allowing us to quickly identify potential problems and prevent their negative consequences.

Application of ultrasonic flaw detectors to detect cracks and defects.

Ultrasonic flaw detectors play an important role in detecting cracks and defects in various materials and structures, including thermal power plant equipment. These instruments use ultrasonic waves to penetrate a material and measure the time it takes for the waves to reflect from internal defects. The use of ultrasonic flaw detectors makes it possible to detect cracks, including the smallest ones, as well as other defects such as inclusions, pores or areas of altered density.

In the context of thermal power plants, ultrasonic flaw detectors are used to test the integrity of materials used in boilers, piping, tanks and other key components. They can detect defects that are not always visible visually, allowing you to quickly identify potential problems such as fatigue cracks, corrosion or structural changes.

The advantages of ultrasonic flaw detectors include high sensitivity to various defects, the ability to conduct deep investigations, and non-impact on the test object, which is especially important for maintaining the integrity and safety of equipment. Such defect detection methods are an important element of maintenance and ensure extended service life and safe operation of equipment in thermal power plants.

Monitoring and diagnostic systems based on IoT (Internet of Things) and data collection.

Monitoring and diagnostic systems based on IoT (Internet of Things) and data collection play an important role in improving the efficiency, reliability and safety of thermal power plants. Using sensors, data acquisition devices and information networks, these systems can continuously monitor equipment performance, environmental conditions and other key indicators.

IoT systems allow you to collect data in real time and transmit it to remote servers for analysis and processing. This makes it possible to quickly respond to changes in equipment condition, identify potential problems and prevent accidents. For example, using IoT systems you can monitor temperature, pressure, vibration and other parameters of equipment operation, as well as control the levels of various substances in cooling systems or fuel tanks.

In addition, IoT-based monitoring and diagnostic systems make it possible to predict the condition of equipment using machine learning algorithms and big data analysis. This helps optimize maintenance schedules, provide early warning of faults and reduce plant downtime.

Thus, monitoring and diagnostic systems based on IoT and data collection play an important role in modern thermal power plants, providing a prompt response to changes in the condition of equipment, increasing its reliability and safety, as well as optimizing maintenance and operation processes.

III. Examples of practical application

Diagnostics of turbines, generators and transformers.

Diagnostics of turbines, generators and transformers in thermal power plants is an important maintenance step and ensures the reliable operation of these key components. For turbines, such diagnostics include checking the condition of the blades, rotor, casing, seals and bearings to identify wear, damage or other problems that may affect their operation and efficiency. For generators, it is important to diagnose the stator and rotor windings, insulation, cooling system, bearings and other key components to identify potential problems such as short circuits, insulation defects or wear. And for transformers, diagnostics include checking the condition of the windings, insulation, cooling system, oil level and other parameters to identify problems such as short circuits, oil leaks or thermal anomalies.

Various methods and technologies can be used to diagnose these components, including visual inspection, temperature measurement, oil analysis, ultrasonic testing, vibration analysis, thermal imaging and others. For example, thermal imaging can be used to detect overheating in the internal components of turbines, generators and transformers, while ultrasonic testing can detect hidden defects in windings or bearings [6-8].

When checking electric motors, you need to pay maximum attention to the following elements:

• bearings - assess their defectiveness by temperature;
• ventilation ducts - check their permeability;
• windings - make sure that there are no turn short circuits.

An example of a thermogram of electric motors is shown in Figure 1.

Inspecting a generator with a thermal imager includes the following steps:

• checking the stator steel for defects;
• determining the temperature of the device and checking abnormal heating zones;
• determination of the temperature of the solder insulation surface;
• determination of brush heating temperature;
• determination of the thermal state of excitation system devices.

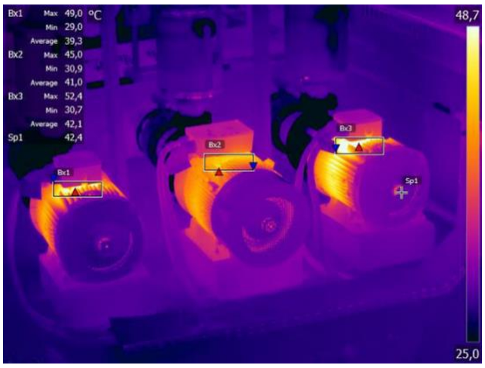

Figure 1: Example of thermogram of electric motors

The thermogram of the electric generator is shown in Figure 2.

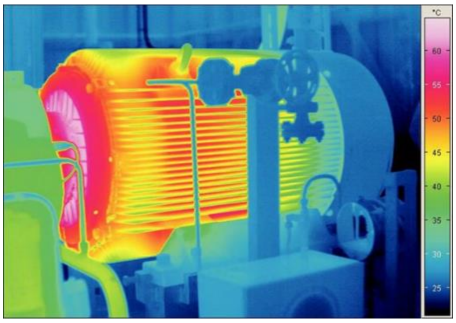

Figure 2: Electric generator thermogram

It is important to note that regular diagnostics and maintenance of these components helps prevent accidents, increase equipment life and ensure reliable operation of thermal power plants in general.

Detection and analysis of defects in electrical circuits and connections.

Detection and analysis of defects in electrical circuits and connections in thermal power plants is essential to ensure the safety and reliability of electrical equipment. Electrical circuits and connections can be subject to various types of defects, such as overheating, corrosion, insulation defects, breaks, short circuits and others. These defects can occur due to various reasons, including improper installation, wear and tear of materials, exposure to external factors, etc.

Various methods and technologies are used to detect and analyze defects in electrical circuits and connections. This includes visual inspection, resistance measurements, thermographic and thermal imaging studies, ultrasonic testing, insulation testing methods and others. For example, thermal imaging cameras can detect overheating in connections or circuit components, which may indicate improper contact or overload. Ultrasonic inspection can be used to identify defects such as cracks or corrosion that may not be visible by visual inspection [9, 10].

DJI's thermal imaging drones are helping users around the world improve productivity and safety (Figure 3). A thermal imaging camera consists of a special lens that transmits infrared frequencies. The camera is also equipped with a thermal sensor and an image processor, which are located in a protective housing. The camera is usually mounted on a drone gimbal, which rotates 360 degrees and helps stabilize the image. As the drone flies over objects, the camera's thermal sensor detects infrared wavelengths and converts them into electronic signals. After receiving the signals, the image processor creates what is called a thermogram or thermographic image, which consists of a color map showing various different temperature values.

The temperature sensor is also called a microbolometer. The structure of this sensor is very complex, absorbs infrared energy and then creates a thermogram based on its measurements.

Analysis of data obtained as a result of diagnostics of electrical circuits and connections allows you to identify problem areas, assess their severity and take corrective action. Regular diagnostics and maintenance of electrical circuits and connections are important to prevent accidents, ensure personnel safety and reliable operation of thermal power plants [11-13]. Monitoring the insulation and thermal conditions of equipment is an important aspect of maintenance and safety in thermal power plants. Insulating electrical systems is critical to preventing short circuits and accidents, and thermal control of equipment helps prevent overheating and damage to components.

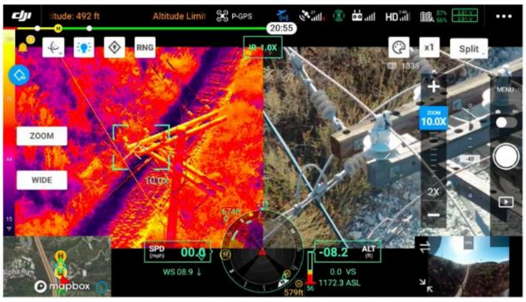

Figure 3: Drones with thermal imaging from DJMonitoring of insulation and thermal conditions of equipment

Insulation monitoring usually involves regularly measuring insulation resistance using specialized testers. This allows you to identify potential insulation defects, such as damage, moisture penetration or contamination, which can lead to current leaks and accidents. Carrying out such measurements allows you to quickly identify problems and take measures to eliminate them, for example, replacing damaged sections of insulation.

When it comes to equipment thermal monitoring, this involves continuously measuring and analyzing the temperatures of critical system components and assemblies. For this purpose, thermal imaging cameras, thermocouples, thermistors and other means of measuring temperature can be used. Continuous thermal monitoring allows you to identify potential problems, such as overheating, insufficient cooling, or thermal imbalance, and take appropriate action, such as improving the cooling system or changing the operating mode of equipment.

In general, monitoring the insulation and thermal conditions of equipment in thermal power plants is an important tool for preventing accidents, ensuring personnel safety and reliable operation of equipment.

Preventing emergency situations and reducing risks in thermal power plants plays a decisive role in ensuring personnel safety, equipment safety and continuity of production processes. For this, various approaches and technologies are used.

Firstly, monitoring and diagnostic systems, such as IoT systems, thermal imaging cameras, ultrasonic flaw detectors and others, make it possible to quickly identify potential problems and deviations in equipment operation before they lead to an emergency. Regular maintenance and diagnostics allow you to detect and correct potential problems at an early stage and prevent them from developing further.

Secondly, strict safety regulations and standards, as well as safety regulations, are the basis for preventing accidents. This includes providing regular instructions and training to staff on the safe handling of equipment, as well as developing and maintaining workplace safety procedures [14, 15].

Another important aspect of preventing accidents is the use of modern technologies and equipment that meet high safety standards and ensure reliable operation. Regular updating and modernization of equipment helps to minimize the risks of emergency situations and ensures a high level of safety in thermal power plants.

IV Conclusions

Increasing the service life of equipment and reducing its maintenance costs are important tasks to ensure efficient and reliable operation of thermal power plants. To achieve these goals, various strategies and methods are used.

Firstly, regular maintenance and preventive maintenance help keep equipment in good condition and prevent malfunctions from occurring. Carrying out regular inspections, replacing worn parts, lubrication and adjustment of mechanisms help prevent premature wear and increase the service life of equipment.

Secondly, the use of modern technologies and innovative solutions makes it possible to increase the efficiency of equipment and reduce the cost of its operation. For example, the use of IoT-based monitoring and diagnostic systems allows you to quickly identify and eliminate potential problems, which helps to increase the service life of equipment and reduce maintenance costs.

In addition, personnel training and compliance with operating and safety regulations help prevent equipment damage and reduce the likelihood of accidents, which also helps to increase its service life and reduce maintenance costs.

Thus, increasing the service life of equipment and reducing the cost of its maintenance is achieved through regular maintenance, the use of modern technologies, personnel training and compliance with operating rules. These measures help keep equipment in good condition, prevent premature wear and improve its efficiency, which ultimately reduces maintenance costs and extends its service life.

Optimizing production processes and improving energy system efficiency in thermal power plants play a key role in ensuring economic efficiency and competitiveness. To achieve these goals, various strategies and technologies are used.

Firstly, the introduction of modern control and automation systems makes it possible to optimize production processes, manage equipment operating modes and make the most efficient use of resources. Automation can reduce energy, raw material and labor costs, and improve the accuracy and reliability of production processes.

Secondly, the use of modern technologies and equipment, such as cogeneration units, solar panels, wind generators and other renewable energy sources, allows us to increase energy efficiency and reduce dependence on traditional energy sources. This reduces energy costs and reduces environmental impact. In addition, optimization of production processes and increased efficiency of power systems is achieved through the implementation of modern methods of management and production planning, as well as data analysis to identify potential for improving production processes and reducing costs.

Thus, optimization of production processes and increasing the efficiency of energy systems in thermal power plants is achieved through the introduction of modern technologies, automation of production processes, use of renewable energy sources and improvement of management and production planning methods. These measures reduce costs, increase the productivity and efficiency of plants, and improve their competitiveness in the energy market.

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