

# The Importance of Diagnostics of Electrical Equipment at Thermal Power Plants for Ensuring the Reliability of Power Systems

**Abstract.** This article discusses the importance of diagnostics of electrical equipment in thermal power plants to ensure the reliability of power systems. Electrical equipment is a key component in the production and transmission of electricity, and its reliable operation is essential to prevent emergency situations and ensure stable operation of power systems. The article discusses diagnostic methods and technologies used to assess the condition of electrical equipment, as well as identify potential problems. The importance of regular maintenance and monitoring of electrical equipment is emphasized to prevent failures and increase the reliability of power systems.

**Streszczenie.** W artykule omówiono znaczenie diagnostyki urządzeń elektrycznych w elektrowniach ciepłych dla zapewnienia niezawodności systemów elektroenergetycznych. Urządzenia elektryczne są kluczowym elementem wytwarzania i przesyłu energii elektrycznej, a ich niezawodne działanie jest niezbędne, aby zapobiec sytuacjom awaryjnym i zapewnić stabilną pracę systemów elektroenergetycznych. W artykule omówiono metody i technologie diagnostyczne stosowane do oceny stanu urządzeń elektrycznych, a także identyfikacji potencjalnych problemów. Podkreśla się znaczenie regularnej konserwacji i monitorowania urządzeń elektrycznych dla zapobiegania awariom i zwiększania niezawodności systemów elektroenergetycznych. (Znaczenie diagnostyki urządzeń elektrycznych w elektrowniach ciepłych dla zapewnienia niezawodności systemów energetycznych)

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

**Słowa kluczowe:** termowizja w podczerwieni, diagnostyka ultradźwiękowa, kamery termowizyjne, system monitorowania, diagnostyka.

## 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].

## Problem setting

*Visual methods for checking equipment condition.*

Visual methods are indispensable for maintaining equipment functionality and ensuring operational safety in various industries. Engineers rely on these techniques to visually inspect equipment for signs of wear, damage, or irregularities, while also considering environmental factors. For instance, they meticulously scrutinize surfaces for cracks, corrosion, leaks, or other indicators of potential issues.

Moreover, comparing the current state of equipment to established standards is another vital aspect of visual inspection. Engineers assess characteristics like color, shape, size, and position, aligning them with prescribed safety and efficacy criteria. For instance, in examining a piping system, engineers meticulously look for signs of play, cracks, or leaks, comparing them against predetermined thresholds.

Incorporating specialized equipment, such as infrared thermal cameras or ultrasonic flaw detectors, further enhances visual inspection capabilities. These tools enable the detection of latent problems that may elude normal visual scrutiny. By swiftly pinpointing potential malfunctions, engineers can intervene preemptively, mitigating the risk of serious incidents or accidents.

*Using Thermal Imaging Cameras to Detect Overheating.*

Thermal imaging cameras serve as invaluable tools for detecting overheating in various systems, including thermal power plants. These cameras utilize infrared radiation to visualize temperature variations across object surfaces. Overheating often signals underlying issues like poor connections, overload, component wear, or cooling system inefficiencies.

Engineers leverage thermal imaging cameras to swiftly scan equipment, pinpointing areas of elevated temperature that may signify trouble. For instance, heightened temperatures at electrical connections could indicate overloads or inadequate contacts, while overheating on pipe surfaces might signal heat transfer or cooling system issues. By promptly detecting such anomalies, engineers

can proactively address potential problems, averting serious damage or accidents.

In essence, the use of thermal imaging cameras for overheating detection proves highly effective in diagnosing equipment conditions within thermal power plants. This proactive approach enables the timely identification of potential issues, thereby preempting adverse consequences and ensuring operational integrity.

#### *Application of ultrasonic flaw detectors to detect cracks and defects.*

Ultrasonic flaw detectors play a pivotal role in identifying cracks and flaws within diverse materials and structures, including equipment found in thermal power plants. These devices harness ultrasonic waves to penetrate materials, gauging the time taken for wave reflections from internal imperfections. By utilizing ultrasonic flaw detectors, even minuscule cracks and defects, alongside inclusions, pores, or density alterations, can be detected.

In the realm of thermal power plants, these flaw detectors are deployed to assess the integrity of materials utilized in crucial components like boilers, piping, and tanks. They excel in identifying imperfections that may escape visual detection, swiftly highlighting potential issues such as fatigue cracks, corrosion, or structural alterations.

Ultrasonic flaw detectors offer several advantages, including heightened sensitivity across a spectrum of defects, the capability to conduct in-depth examinations, and their non-intrusive nature, ensuring equipment integrity and safety. Incorporating such defect detection methodologies into maintenance protocols is vital, fostering prolonged service life and secure operation of equipment within thermal power plants.

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

Monitoring and diagnostic systems leveraging IoT (Internet of Things) technology and data collection are pivotal in enhancing the efficiency, reliability, and safety standards of thermal power plants. By employing sensors, data acquisition devices, and interconnected networks, these systems ensure continuous monitoring of equipment performance and environmental conditions.

IoT systems enable real-time data collection and transmission to remote servers for analysis and processing. This facilitates prompt responses to fluctuations in equipment condition, enabling the timely identification of potential issues and accident prevention. For instance, IoT systems can monitor parameters like temperature, pressure, vibration, and substance levels in cooling systems or fuel tanks.

Moreover, IoT-based monitoring and diagnostic systems harness machine learning algorithms and big data analysis to predict equipment conditions. This proactive approach optimizes maintenance schedules, offers early fault warnings, and minimizes plant downtime.

### **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.

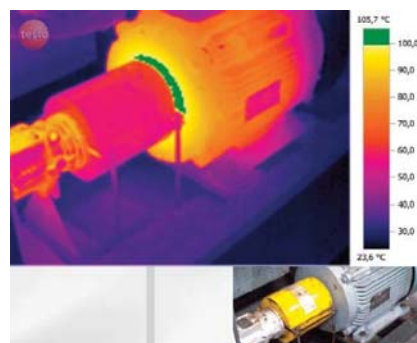


Fig.1. Example of thermogram of electric motors

Inspecting a generator using a thermal imager involves several key steps to ensure thorough evaluation:

1. Checking Stator Steel for Defects: The thermal imager is used to examine the stator steel for any irregularities or defects that may affect performance or safety.
2. Determining Device Temperature and Identifying Abnormal Heating Zones: By measuring temperatures across the device, abnormal heating zones can be identified, which may indicate potential issues such as overload or insulation breakdown.
3. Assessing Solder Insulation Surface Temperature: The thermal imager is utilized to determine the temperature of the solder insulation surface, helping to detect any areas of overheating or degradation.
4. Measuring Brush Heating Temperature: Brush heating temperature is determined using the thermal imager, allowing for the identification of any excessive heat generation that could lead to brush wear or malfunction.
5. Evaluating Thermal State of Excitation System Devices: The thermal imager is employed to assess the thermal condition of excitation system devices, helping to detect any abnormalities or overheating that may affect performance or reliability.

By following these steps and utilizing thermal imaging technology, engineers can effectively inspect generators, identify potential issues, and take preventive measures to ensure optimal performance and safety [9-12].

#### *Detection and analysis of defects in electrical circuits and connections.*

Detection and analysis of defects in electrical circuits and connections within thermal power plants are crucial for maintaining equipment safety and reliability. These defects, including overheating, corrosion, insulation faults, breaks, and short circuits, can arise from factors like improper

installation, material degradation, or environmental exposure.

A variety of methods and technologies are employed for defect detection and analysis. These encompass visual inspections, resistance measurements, thermographic and thermal imaging assessments, ultrasonic testing, insulation testing, among others. For instance, thermal imaging cameras are effective in identifying overheating in connections or circuit components, indicating potential issues like improper contact or overload. Ultrasonic inspection can detect hidden defects such as cracks or corrosion that may elude visual inspection.

Innovative solutions like DJI's thermal imaging drones are increasingly utilized worldwide to enhance productivity and safety in defect detection (Figure 2). These drones are equipped with specialized thermal imaging cameras featuring lenses that capture infrared frequencies. The thermal sensor and image processor within the camera, housed protectively, detect infrared wavelengths and convert them into electronic signals. The resulting thermographic image, or thermogram, displays a color map representing various temperature values, aiding in defect identification and analysis [13-16].

By leveraging these advanced technologies, thermal power plants can effectively detect and analyze defects in electrical circuits and connections, ensuring enhanced safety and reliability of equipment operations.

The temperature sensor, also known as a microbolometer, plays a critical role in thermal imaging technology. Its intricate structure enables it to absorb infrared energy and subsequently generate a thermogram based on its measurements.

Analyzing the data acquired through diagnostics of electrical circuits and connections enables the identification of problematic areas, the assessment of their severity, and the implementation of corrective measures. Regular diagnostics and maintenance of these components are imperative to prevent accidents, ensure personnel safety, and uphold the reliable operation of thermal power plants.

Monitoring the insulation and thermal conditions of equipment stands as a pivotal aspect of maintenance and safety protocols in thermal power plants. Adequate insulation of electrical systems is essential for averting short circuits and potential accidents. Additionally, thermal control of equipment aids in preventing overheating and damage to components, thus safeguarding the integrity and efficiency of plant operations.



Fig.2. Drones with thermal imaging from DJIMonitoring of insulation and thermal conditions of equipment

Insulation monitoring is typically conducted through regular measurements of insulation resistance using specialized testers. This practice enables the detection of potential insulation defects such as damage, moisture ingress, or contamination, which can lead to current leaks and safety hazards. By promptly identifying such issues, corrective actions such as replacing damaged insulation sections can be taken.

Equipment thermal monitoring involves continuous measurement and analysis of temperatures in critical system components and assemblies. Thermal imaging

cameras, thermocouples, thermistors, and other temperature measurement tools are utilized for this purpose. Continuous thermal monitoring facilitates the early detection of potential problems such as overheating, inadequate cooling, or thermal imbalances, allowing for appropriate interventions such as optimizing cooling systems or adjusting equipment operating modes.

Overall, monitoring insulation and thermal conditions in thermal power plant equipment is vital for accident prevention, ensuring personnel safety, and maintaining operational reliability. Preventing emergencies and mitigating risks in thermal power plants relies on a multifaceted approach:

1. Monitoring and diagnostic systems, including IoT systems, thermal imaging cameras, and ultrasonic flaw detectors, enable the swift identification of potential issues before they escalate into emergencies. Regular maintenance and diagnostics allow for the early detection and resolution of problems, preventing further escalation.
2. Adherence to strict safety regulations and standards, alongside comprehensive safety protocols, forms the foundation for accident prevention. This entails providing regular training to staff on equipment safety procedures and maintaining workplace safety protocols.
3. Utilizing modern technologies and equipment that adhere to high safety standards and ensure reliable operation is crucial. Regular equipment updates and modernization efforts help minimize the risk of emergencies and uphold safety levels in thermal power plants.

By integrating these approaches, thermal power plants can effectively mitigate risks, prevent accidents, and ensure the safety and reliability of their operations

## Conclusions

Increasing the service life of equipment and reducing maintenance costs are crucial objectives for ensuring the efficient and reliable operation of thermal power plants. Achieving these goals involves employing various strategies and methods:

**Regular Maintenance and Preventive Maintenance:** Conducting regular inspections, replacing worn parts, lubricating, and adjusting mechanisms help prevent premature wear and prolong the service life of equipment.

**Utilization of Modern Technologies:** Implementing innovative solutions such as IoT-based monitoring and diagnostic systems enables quick identification and resolution of potential problems, thus extending equipment service life and reducing maintenance costs.

**Personnel Training and Compliance with Operating and Safety Regulations:** Ensuring personnel are well-trained and adhering to safety protocols minimizes equipment damage and reduces the likelihood of accidents, ultimately increasing equipment service life and reducing maintenance costs.

**Optimizing Production Processes and Improving Energy System Efficiency:** Enhancing economic efficiency and competitiveness in thermal power plants involve various strategies:

**Introduction of Modern Control and Automation Systems:** Optimizing production processes, managing equipment operating modes, and maximizing resource utilization through automation reduces energy, raw material, and labor costs while improving process accuracy and reliability.

**Utilization of Modern Technologies and Equipment:** Incorporating renewable energy sources such as

cogeneration units, solar panels, and wind generators increases energy efficiency, reduces dependence on traditional energy sources, and lowers energy costs while mitigating environmental impact.

Implementation of Advanced Management and Production Planning Methods: Optimizing production processes and enhancing power system efficiency through data analysis and modern management techniques identify opportunities for process improvement and cost reduction, thereby enhancing productivity and competitiveness in the energy market.

In summary, increasing equipment service life and reducing maintenance costs in thermal power plants are achieved through a combination of regular maintenance, utilization of modern technologies, personnel training, and adherence to safety regulations. Similarly, optimizing production processes and improving energy system efficiency involve leveraging modern technologies, automation, renewable energy sources, and advanced management methods to enhance productivity, efficiency, and competitiveness in the energy sector.

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