



ANALYSIS OF SCIENTIFIC RESEARCH ON DIAGNOSTICS OF THE TECHNICAL CONDITION OF OIL POWER TRANSFORMERS

I.K.Ismoilov

Fergana polytechnic institute, Fergana, Uzbekistan

E-mail: i.ismoilov@ferpi.uz

Annotation: This article is a review of scientific research devoted to diagnosing the technical condition of oil-based power transformers. Both traditional methods of analysis, based on the study of oil samples and electrical characteristics, and promising directions using the analysis of vibroacoustic signals and machine learning are considered.

Keywords: Oil transformer, diagnostics, technical condition, oil analysis, electrical characteristics, vibroacoustic analysis, machine learning.

Introduction: The reliable operation of oil-filled power transformers is a critically important factor in the functioning of power systems. Diagnosing their technical condition allows for the timely identification of defects and prevention of emergency situations. Oil-filled power transformers are indispensable components of power systems, ensuring the transmission of electricity over various distances. Their reliable operation is a crucial factor for the uninterrupted functioning of power supply. Diagnosing the technical condition of transformers involves a set of measures aimed at identifying defects and assessing their potential impact on the equipment's performance.

Timely diagnostics allow for:

- Preventing emergency situations: Early detection of defects enables taking measures to eliminate them and prevent emergency shutdowns, which can lead to significant economic losses and even pose a threat to human life.

- Increasing operational efficiency: Regular diagnostics help optimize transformer operating modes, reduce losses, and extend their service life.

- Conducting scheduled maintenance: Diagnostic results are used to plan maintenance and preventive work, minimizing equipment downtime and optimizing maintenance costs.

There is a wide range of diagnostic methods for oil-filled power transformers:

- Oil sample analysis: Studying the physicochemical properties of oil helps identify insulation degradation products that indicate the presence of defects.

- Measurement of electrical characteristics: Analyzing parameters such as winding resistance, transformation ratio, no-load and load currents provides information about the condition of insulation, windings, and the transformer's magnetic system.

- Vibroacoustic control: Analyzing acoustic signals generated during transformer operation helps identify mechanical defects such as loose fittings and deformations of the active part.

- Thermographic control: Using thermal imagers helps detect local overheating in the transformer, which may indicate insulation or contact connection defects.

- Infrared diagnostics: IR diagnostics allow detecting oil leaks, insulation cracks, and other defects that are not visible visually.

The choice of diagnostic method depends on various factors such as:

- Transformer type and capacity
- The type of suspected defect
- Availability of equipment and qualified personnel
- Economic feasibility

In modern conditions, comprehensive diagnostic methods that combine various research techniques are gaining increasing importance. This approach provides more complete and accurate information about the transformer's technical condition.

The development of diagnostic methods for oil-filled power transformers is an important task, the solution of which will increase the reliability and efficiency of power systems.

Aim of the Article. The aim of this article is to analyze modern scientific research in the field of diagnostics of oil-filled power transformers.

Task Formulation. To analyze existing methods for diagnosing the technical condition of oil-filled power transformers, assess their effectiveness, and explore prospects for development.

Results of the analysis of scientific research on the diagnostics of oil-filled power transformers

1. Traditional diagnostic methods:

- Oil Analysis: One of the most common diagnostic methods. It allows the identification of defects such as overheating, insulation decomposition, and corrosion of metal parts. The most informative indicators include dissolved gas content, acid number, and viscosity.
- Measurement of electrical characteristics: This method evaluates the condition of insulation, windings, and the transformer's magnetic system. Parameters such as winding resistance, transformation ratio, no-load, and load currents are measured. Analyzing the dynamics of these parameters provides valuable information about the transformer's condition.

2. Promising diagnostic methods:

- Vibroacoustic Analysis: Based on analyzing acoustic signals generated during transformer operation, it identifies mechanical defects such as loose fittings, deformations of the active part, and winding vibrations. It is more sensitive than traditional methods, allowing early detection of defects.
- Machine learning: Used for processing and analyzing data obtained by various diagnostic methods, machine learning helps build more comprehensive diagnostic models, increasing the accuracy and reliability of transformer condition assessments. It is actively developing and holds significant potential for further enhancing diagnostics.

3. General trends in diagnostics development:

- Comprehensive approach: Combining various diagnostic methods provides the most complete and accurate information about the transformer's condition.
- Automation: The development of automated diagnostic systems reduces the time and labor required for diagnostic work.
- Artificial intelligence: Applying AI methods for processing and analyzing diagnostic data enhances the accuracy and efficiency of diagnostics.

Discussion: Discussion of modern methods and prospects for the development of diagnostics of oil-filled power transformers:

1. Analysis of traditional methods:

- Oil analysis:
 - Advantages: Simplicity and accessibility. Ability to identify various defects. Established standards for result assessment.
 - Disadvantages: Not always effective in early defect detection. Results can be ambiguous. Requires qualified personnel.
- Measurement of electrical characteristics:
 - Advantages: Simplicity and accessibility. Informative indicators. Possibility of continuous monitoring.
 - Disadvantages: Not always precise in defect localization. Sensitive to external factors. Requires specialized equipment.

2. Evaluation of promising methods:

- Vibroacoustic analysis:
 - Advantages: High sensitivity to mechanical defects. Early defect detection. Non-invasive method.

- Disadvantages: Complexity in result interpretation. External noise interference. Requires methodology development for different transformer types.

- Machine learning:

- Advantages: Ability to process large data volumes. Increased diagnostic accuracy and reliability. Process automation.

- Disadvantages: Requires extensive training data. Algorithm development complexity. Needs result verification and validation.

3. Current challenges and development directions:

- Developing comprehensive diagnostic techniques combining various methods.

- Improving data processing and analysis methods.

- Creating AI-based automated diagnostic systems.

- Developing standardized diagnostic methodologies and protocols.

- Enhancing personnel qualification in diagnostics.

4. Expected results:

- Increased diagnostic accuracy and reliability of oil-filled power transformers.

- Reduced risk of emergency shutdowns.

- Improved efficiency of power systems.

- Extended transformer service life.

- Lower maintenance and repair costs.

Conclusion

Modern scientific research aims to improve the methods for diagnosing oil-filled power transformers. A comprehensive approach combining traditional oil analysis and electrical characteristic measurement with new methods such as vibroacoustic analysis and machine learning enhances diagnostic efficiency and ensures reliable operation of power systems.

References:

1. Shamsiev K. A., Shamsiev B. K., Khamidov S. V. Increasing the reliability of the united power systems of central Asia in conditions of energy transition //E3S Web of Conferences. – EDP Sciences, 2023. – T. 384. – C. 01020.
2. Nasirov T. K. et al. Problems of ensuring reliability and sustainable development of the United energy system of Central Asia under the conditions of energy consumption growth //E3S Web of Conferences. – EDP Sciences, 2023. – T. 461. – C. 01038.
3. Yusupov D. T. et al. Development of a simulation model for assessing the technical condition of oil power transformers by measuring vibroacoustic parameters //E3S Web of Conferences. – EDP Sciences, 2024. – T. 510. – C. 04014.
4. Zalizny D. I. The diagnosis technique of abnormal heating of power capacitors //energetika. Proceedings of CIS higher education institutions and power engineering associations. – 2016. – T. 59. – №. 6. – C. 563-572.
5. Yusupov D. T. et al. Development of a simulation model for assessing the technical condition of the magnetic circuit of oil power transformers by measuring the temperature of the tank and the external environment //E3S Web of Conferences. – EDP Sciences, 2024. – T. 510. – C. 04013.
6. Lankin A., Baklanov A., Lankin I. Analysis of diagnostic methods and functional state monitoring of power oil transformers in electrical substations //E3S Web of Conferences. – EDP Sciences, 2019. – T. 135. – C. 01021.
7. Wang J. et al. Review on evolution of intelligent algorithms for transformer condition assessment //Frontiers in Energy Research. – 2022. – T. 10. – C. 904109.
8. Gruntovich N. V. et al. Development of methodological support for diagnosing energy efficiency //Energy and Management. – 2017. – T. 1. – №. 94. – C. 8-13.
9. Грунтович Н. В., Петров И. В., Колесников П. М. Компьютерные системы технического диагностирования маслонаполненных трансформаторов //Вестник Гомельского государственного технического университета им. ПО Сухого. – 2013. – №. 4 (55). – С. 094-099.
10. Yusupov D. et al. Investigation of factors influencing the operational characteristics of traction

- transformers //E3S Web of Conferences. – EDP Sciences, 2021. – Т. 274. – С. 13007.
11. Роженцова Н. В., Галяутдинова А. Р. Анализ методов диагностики силовых трансформаторов //Энергетика и энергосбережение: теория и практика. – 2018. – С. 430.1-430.4.
 12. Sikorski W., Walczak K. Power transformer diagnostics based on acoustic emission method //Acoustic emission-research and applications. – 2013. – Т. 1. – С. 1-13.
 13. Чупак Т. М. Прогнозирование технического состояния силовых маслонаполненных трансформаторов //дис. на соискание ученой степени канд. техн. наук. – 2007. – Т. 5. – №. 02.
 14. Christina A. J. et al. Causes of transformer failures and diagnostic methods–A review //Renewable and Sustainable Energy Reviews. – 2018. – Т. 82. – С. 1442-1456.
 15. Yusupov D. T. et al. Cleaning of transformer oils using the electric field //IOP Conference Series: Earth and Environmental Science. – IOP Publishing, 2023. – Т. 1231. – №. 1. – С. 012024.
 16. Исмоилов И. К., Халилова Ф. А. Регулирование активной и реактивной мощности синхронного генератора при подключении к сети //Universum: технические науки. – 2021. – №. 1-3. – С. 21-25.
 17. Туйчиев З. З. и др. Проблемы качества электроэнергии в системах электроснабжения //Проблемы науки. – 2019. – №. 10. – С. 15-18.
 18. Исмоилов И. К., Турсунов Д. А. Применение методов робастного управления в системах регулирования синхронных генераторов //Universum: технические науки. – 2020. – №. 12-5. – С. 28-31.
 19. Yusupov D. et al. Express diagnostics of power oil transformers by vibroacoustics and partial discharges //E3S Web of Conferences. – 2023. – Т. 434. – С. 01027.
 20. Yusupov D. T. et al. Development of a simulation model for assessing the technical condition of oil power transformers by measuring vibroacoustic parameters //E3S Web of Conferences. – 2024. – Т. 510. – С. 04014.
 21. Қодиров А.А., Комолдинов с. с. реактивная мощность в оценке надежности энергосистем, ограничение нагрузки и компенсация //экономика. – С. 1124-1130.
 22. Kobilov M., Kodirov A. problems of detecting single-phase grounding in low voltage networks //universum. – с. 98-102.