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Parameter Reliability Assessment of Electric Motors

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Abstract

This article covers the issues of determining the diagnostic parameters of electric motors, predicting the state of failure and its prevention, effective usage of electric equipment and increasing its reliability. It analyzes the state of failures of asynchronous motors used in our country and gives appropriate conclusions.

The main failure factors of electrical equipment were analyzed, their technical condition was assessed, and the main diagnostic parameters causing the failure state were determined, and the necessity of the parameter of the influence of the operational period on useful work coefficient was substantiated. The most common type of damage to electric motors was the burnout of the insulation or black discoloration of the coil insulation - 78.9%. In the electric motor failure case, there was three-phase burnout at 37.7%, two-phase burnout at 21.3%, and single-phase burnout at 19.9%.

Keywords: agriculture; technological process; electric motor; failure; operation; interphase circuit; insulation resistance; rotor braking

Introduction

Reliability parameters of electric motors refer to their ability to maintain specified rated for a long time without interruption. In this case, the motor must be correctly selected having an appropriate level of protection and a reliable power supply. In manufacturing industries of our republic, asynchronous motors with a power of 0.25 - 110 kW are used, and in irrigation and reclamation pumping stations, asynchronous motors with a power of 50 - 800 kW are used [1-3].

The purpose of the study is to determine the diagnostic parameters of electric motors, to predict the state of failure and its prevention, and to increase the effective use and reliability of electric equipment based on the minimization of downtime.

The analysis of the main factors that have a negative impact on electrical equipment and their operating modes, operating conditions, types of damage, causes of failure, and reliability in production conditions are presented in this paper.

The results of the analysis show that the most common type of damage was insulation burn out or black discoloration of the insulation of the pipe - 78.9%. In the case of electric motor failure, three-phase burnout accounted for 37.7%, two-phase burnout - 21.3%, and single-phase burnout - 19.9% (compared to the total number of electric motors in the research object) [1, 4-13].

Types of damage were analyzed on the basis of a survey conducted among electrotechnical service workers: suitability of protective equipment and motor characteristics, organizational and technical level of operation, phase interruptions, etc. It was identified that the most likely failure of motors in short-term and short-repetitive modes of operation occurs due to adverse environmental effects.

Rotor braking occurs due to electric motors overloading, stalling or failure to start, resulting in 28.4% of electric motor failures. This results in 4.9% failure due to wear and compression of the bearing parts. Decrease in insulation resistance occurs under the influence of moisture, disinfectant solutions and aggressive gases, therefore causes 22.6% of failures, and connections due to interphase and body contact cause 7.4% of failures (Fig. 1) [1, 14-22].

In short, in order to increase the reliability of operation, it is necessary to correctly select the electromotive power for working machines, clearly define the operating modes, correctly select and adjust control and protective devices, timely technical inspection, current and major repairs. In particular, it is recommended to use protective devices aimed at preventing switching overvoltage and reducing the degree of impact (curvature and amplitude). In most cases, when turning off electrical equipment, an electric arc occurs, and the burning process of the arc corresponds to the moment of disconnection of the contacts. In this case, the magnitude of the current and voltage remains within the amplitude magnitude range from the value before the switching.

By determining the reliability factors of electrical equipment, predicting the state of failure and its prevention, and reducing downtime, it is possible to achieve the effective use and reliability of electrical equipment in agriculture and water management.

An important task is the optimal selection of parameters when developing a method for diagnosing electrical equipment, as well as parameters characterizing the diagnostic and technical condition of the object.

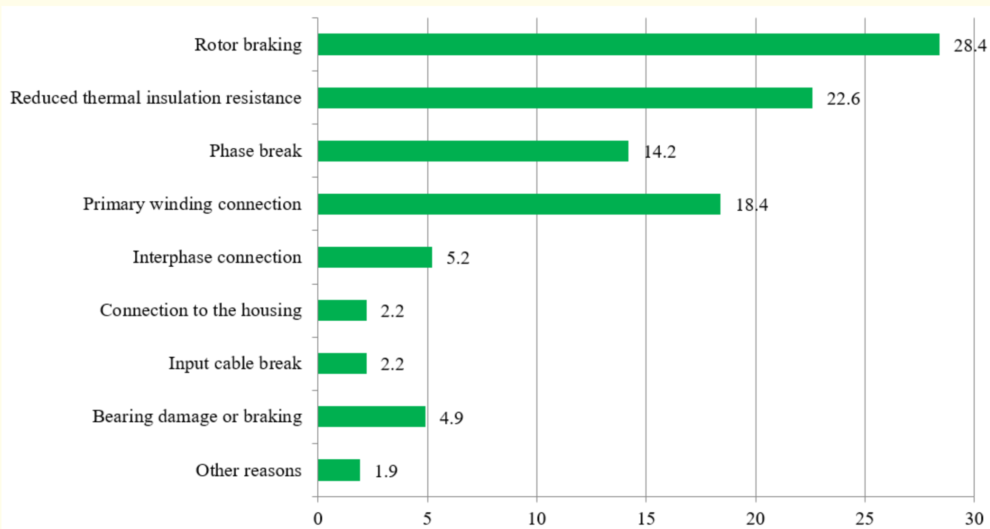

Figure 1: Probable causes of electric motor failure (in percentage).

The deterioration of insulation conditions and the increase in load beyond the power capacity, as well as the increase in current in the windings, are various critical abnormal conditions leading to the overheating of asynchronous motor windings. In the conditions of agricultural production, the insulation of electric motors is mainly affected by the high humidity and high concentration of aggressive gases in the air, especially during commutation pulses. The main causes of mechanical damage are directly related to the bearings. About 75...96% of all disconnection causes are attributed to stator windings, with stator winding burnout accounting for 46...80% and insulation failure accounting for 16...44% [1, 23-31].

The analysis of sources on insulation damage indicates the following typical characteristics: insulation breakdown (burnout), inter-winding short circuit, short circuit to the casing, and interphase circuit. It should be emphasized that insulation burnout occurs more frequently compared to insulation perforation (Figure 2).

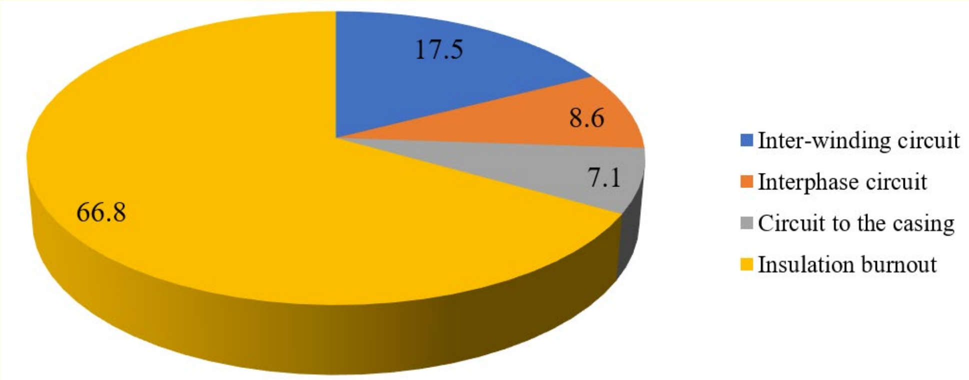

Figure 2: Types of damages to electric motors (in percent).

The provided information does not fully reflect the actual reality of the production process, as the causes of damage and occurrence locations vary depending on different operating conditions. Additionally, the reliability and accuracy level of protective devices for electric motors, the consequences of damage development, and other factors are also relevant. For example, in the case of inter-winding short circuits in the stator winding of an asynchronous motor, the motor current remains almost unchanged, and the protective device does not activate, while failure extends to the level of inter-phase or case short circuit and insulation burnout (in 80% cases). This indicates the insufficient effectiveness or absence of protective devices in such emergency conditions.

To carry out a complete diagnosis of electrical equipment, it is necessary to measure all the parameters of the object, but to carry out such measurements, a sufficient number of measuring instruments and time are required, and the efficiency of the conducted diagnostics may decrease while costs may increase. Therefore, the most important parameters are selected and optimal number and sequence is determined. In this case, the costs should be minimal and the diagnostic results should be reliable. Sometimes, despite a great amount of information, a lot of costly parameters may not be obtained.

It can be observed that the selection of diagnostic parameters for the corresponding electrical equipment is the optimized parameters for solving this problem. When choosing a series of diagnostic parameters, usually all the parameters that can be measured and characterize the technical condition of electrical equipment are expressed by physical quantities.

The main diagnostic parameters for evaluating the technical condition of the electric motor are determined by diagnostic parts such as the insulation of the stator core to the body, inter-phase insulation, inter-winding insulation, stator core, and rotor core. However, the useful work coefficient (UWC) influence parameter of the service life has not been thoroughly studied yet. To overcome this problem, the UWC influence parameter of the operational period was determined in our research. The effect of UWC on the service life of electrical equipment can have a significant negative impact on labor productivity and work efficiency.

Three types of problems are solved in electrical equipment diagnostics. Determining the performance of the product, establishing the remaining life, and determining the causes of the malfunction.

The main issue in the development of diagnostic technology for electrical equipment is to determine the diagnostic sequence of details and parts and the number of parameters to be measured.

To get the most complete information about the technical condition of electrical equipment, it is necessary to conduct a complete diagnosis of all its parts, but the costs for diagnostic work will be high. If diagnostics are carried out on a limited scale, all faults may go undetected, and unexpected shutdowns may occur at the facility causing significant damage.

Diagnostics of electrical equipment includes:

- Visual and document verification. Diagnostics of the equipment begins with a visual inspection. Clear signs of physical damage, loose connections, corrosion and overheating are identified. Along with this, special attention is paid to unusual smells or sounds that may cause problems;
- Equipment maintenance records and documentation should be reviewed. Previous failures, repair, or maintenance procedures are checked. This data can provide valuable information about the history of the equipment;
- Failure test. Fault finding test methods are used. For example, ultrasound to detect internal defects or cracks. Infrared thermography to detect hot spots or temperature anomalies. Electrical tests to measure resistance and insulation resistance;
- Vibration analysis. For rotating electrical equipment such as electric motors or generators, a vibration analysis is performed to determine the stability of the foundation and the rotation of the bearings. Abnormal vibrations indicate problems with components;
- Oil analysis. The condition of oil and lubricants for electrical equipment is assessed, and the presence of contamination and additional particles in the oil is determined. An oil analysis is performed to identify problems such as deterioration of oil quality;
- Electrical test and insulation test. In order to prevent a short circuit, the insulation resistance is determined. When checking the integrity of the pipe insulation, an insulation resistance measurement test is carried out using special tools; An electrical test is conducted to evaluate the performance of electrical equipment. This includes measuring voltage, current, power, frequency and other parameters;
- Functional test. Functional tests are performed to ensure that electrical equipment operates properly. Safety mechanisms, control systems, and safety interlocks are checked for proper operation;
- Data analysis. Data collected during the monitoring of sensor and online diagnostic systems are analyzed. Deviations from the expected value and norms are determined to identify the main problems;
- Interpretation and diagnosis. Based on the data analysis, a diagnosis of the condition of the equipment is made. It has been established that the equipment is in good condition and requires urgent maintenance or repair or replacement;
- Report. The diagnosis is documented with test results and a diagnosis report. Recommendations for necessary actions such as maintenance, repair, or replacement are included;
- Maintenance, repair or replacement. Recommended maintenance, repair, or replacement actions are performed to resolve identified problems. Best practices and safety guidelines are followed during the process;
- Monitoring and tracking. After maintenance or repair, equipment performance and condition monitoring is continued to ensure long-term reliability.

Conclusion

- The main failure factors of electrical equipment were analyzed, their technical condition was assessed, and the main diagnostic parameters causing the failure state were determined, and the necessity of the parameter of the influence of the operational period on UWC was substantiated;
- The most common type of damage to electric motors was the burnout of the insulation or black discoloration of the coil insulation - 78.9%. In the electric motor failure case, there was three-phase burnout at 37.7%, two-phase burnout at 21.3%, and single-phase burnout at 19.9%.

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