

Electrical Test and Relay Protection Analysis of Power Transformer

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ABSTRACT

In this paper, the electrical test and relay protection of power transformer are deeply analyzed. Firstly, the purpose, classification and common methods of electrical test are expounded, and the processing methods of test results are discussed. Then, the basic principle, device classification and configuration method of relay protection are discussed. Furthermore, the relationship between electrical test and relay protection is analyzed, and their application and significance in power transformer protection are discussed. This paper aims to provide theoretical support for improving the operation safety and reliability of power transformers.

KEYWORDS

Power Transformer; Electrical Test; Relay Protection; Correlation Analysis; Operation Safety.

1. INTRODUCTION

As the core equipment of power system, the stability and safety of power transformer's operation state are directly related to the reliable operation of the whole power system. In order to ensure the normal operation of power transformer, electrical test and relay protection have become indispensable means. Electrical test can evaluate key parameters such as insulation performance and winding condition of transformer, and provide data support for preventive maintenance of transformer. The relay protection can act quickly when the transformer fails, isolate the fault and prevent the fault from spreading, thus protecting the stability of the power system. In this paper, the electrical test and relay protection of power transformer will be deeply analyzed, and its principle, method and application will be discussed in order to provide theoretical support and practical guidance for the safe operation of power system.

2. THE ELECTRICAL TEST OF POWER TRANSFORMER

2.1. The Purpose and Classification of Electrical Test

As an indispensable key equipment in the power system, the operation state of power transformer directly affects the security and stability of the power system. As an important means to evaluate the performance of transformer, electrical test aims to ensure that the insulation performance, operation characteristics and bearing capacity of transformer meet the design requirements, so as to prevent potential operation failures. Electrical tests are mainly divided into preventive tests and destructive tests. Preventive tests, such as insulation resistance measurement and dielectric loss factor test, are carried out under the normal operation of the transformer, and the main purpose is to find potential defects inside the transformer, such as insulation aging and moisture. This kind of test usually does not need to apply excessive voltage to the transformer, so it has little influence on the normal

operation of the transformer. Destructive tests, such as lightning impulse test and short circuit withstand test, need to apply higher voltage or current to the transformer to simulate the extreme conditions that the transformer may encounter in actual operation. This kind of test can directly reflect the electrical performance of the transformer, but it may also cause some damage to the insulation structure of the transformer. Therefore, destructive tests are usually carried out after preventive tests are qualified to ensure that transformers can withstand these extreme conditions. The electrical test can not only evaluate the current state of the transformer, but also provide an important reference for the maintenance and overhaul of the transformer. Reasonable test scheme and accurate test results are of great significance to ensure the safe and stable operation of power system.

2.2. Common Methods and Techniques of Electrical Test

In the power system, the electrical test of power transformer is a vital work, which is directly related to the safe and stable operation of transformer. The purpose of electrical test is to evaluate the insulation performance, electrical parameters and operating state of transformer through a series of detection means, so as to prevent potential faults and accidents. The common methods and techniques of electrical test cover many aspects. Insulation resistance test is one of the most basic items. By measuring the insulation resistance value of transformer, we can judge whether its insulation state is good or not. The dielectric loss tangent test is used to evaluate the electrical properties of insulating materials, which reflects the energy loss of insulating materials under the action of electric field. DC resistance test is an important means to check the quality of transformer winding. By measuring the DC resistance of winding, the connection state of winding and the quality of conductor can be indirectly judged. The transformer ratio test is used to confirm whether the transformer ratio meets the design requirements, which is very important to ensure the voltage stability and power quality of the power system. The short-circuit impedance test is used to evaluate the short-circuit resistance of the transformer. By measuring the impedance value during short-circuit, the withstand capacity of the transformer during short-circuit fault can be judged. In addition, no-load current and no-load loss tests are also important means to evaluate the performance of transformers, which reflect the electrical characteristics of transformers in no-load state. In addition to the above basic testing methods, there are a series of advanced testing technologies, such as partial discharge testing and winding deformation testing, which can reveal the potential problems of transformers more deeply and provide strong support for fault diagnosis and preventive maintenance of transformers.

The electrical test of power transformer is a systematic and complicated work, which requires testers to have solid professional knowledge and rich practical experience. Through scientific and rigorous test methods and technical means, we can ensure the safe and reliable operation of transformers and provide a solid guarantee for the stable operation of power systems.

2.3. Analysis and Processing of Electrical Test Results

The analysis and processing of electrical test results is an important link to ensure the stability and safety of power transformer operation. When analyzing the electrical test results, the test data should be comprehensively and carefully reviewed to ensure the accuracy and reliability of the data. This includes detailed examination of key parameters such as voltage, current, power and impedance, as well as in-depth analysis of complex data such as waveform and spectrum. Through the analysis of these data, we can preliminarily judge the insulation performance, winding state, iron core condition and operating efficiency of the cooling system of the transformer. When dealing with these data, we need to use professional electrical knowledge and rich practical experience. For example, by comparing historical data, we can find the changing trend of transformer performance; By comparing and analyzing the data of different test items, the potential problems that may exist inside the transformer can be revealed. In addition, the influence of external environmental factors such as temperature and humidity on the test results, as well as possible operational errors and instrument errors during the test should also be considered. On the basis of the analysis results, targeted treatment

measures should be formulated. For the problems found, relevant components should be repaired or replaced in time to ensure the normal operation of the transformer. At the same time, daily maintenance and regular inspection should be strengthened to prevent the recurrence of similar problems. Through the implementation of these measures, the safe and stable operation of power transformers can be ensured, which provides a strong guarantee for the reliable power supply of the power system.

3. THE BASIC PRINCIPLE AND CONFIGURATION OF RELAY PROTECTION

3.1. The Basic Concept and Function of Relay Protection

Basic concept and function of relay protection in power system, power transformer is the core equipment of energy conversion and transmission, and its safe and stable operation is very important. And relay protection is an important barrier to ensure the safety of transformer and the whole system. Simply put, relay protection is to detect the fault or abnormal state in the power system, and cut off the fault part or give an alarm through corresponding actions, so as to reduce the impact of the fault on the system and protect the safety of equipment and system. The basic principles of relay protection can be summarized as selectivity, quickness, sensitivity and reliability. Selectivity means that when a fault occurs, the relay protection device can accurately select the equipment or line where the fault point is located for removal to avoid unnecessary power failure. Quick action requires the protection device to act quickly after detecting the fault, so as to limit the scope and duration of the fault. Sensitivity refers to the ability of protection device to respond to faults, that is, it can detect and react in time at the early stage of faults. Reliability is the most basic requirement of the protection device, which requires the protection device not to misoperate in normal operation, but to act reliably in case of failure. In practical application, the configuration of relay protection device needs to be customized according to the specific situation of power system. For power transformers, differential protection, over-current protection, gas protection and other protection methods are usually configured to deal with different types of faults. Through accurate current and voltage sampling and logical judgment, these protection methods ensure that the transformer can act quickly and accurately when it fails, thus protecting the safety of the transformer and ensuring the stable operation of the whole power system.

3.2. Classification and Characteristics of Relay Protection Devices

Relay protection devices are an indispensable part of the power system, and they are responsible for acting quickly and accurately when the power system fails, so as to prevent the fault from expanding and ensure the safe and stable operation of the power system. According to different action principles and structural characteristics, relay protection devices can be divided into many types, and each type has its own unique application scenarios and advantages. Electromagnetic relay protection devices are the most common forms of protection in early power systems. They use the principle of electromagnetic induction to make contacts act by electromagnetic force when the current or voltage exceeds the preset value, thus realizing the protection function. This protection method is simple and reliable, but its response speed is slow and it is greatly influenced by environmental factors. With the development of technology, electronic relay protection devices have gradually replaced electromagnetic protection. Electronic protection uses microprocessor and digital circuit, which can realize more complicated logic judgment and higher action speed. They can not only protect current and voltage, but also monitor frequency, phase and other parameters to provide more comprehensive protection. In addition, there are relay protection devices based on artificial intelligence technology, which can adaptively adjust the protection strategy and improve the sensitivity and selectivity of protection through algorithms such as machine learning and neural network. They have broad application prospects in complex power systems. Generally speaking, the classification of relay

protection devices is diverse, and each type has its own unique characteristics and applicable scenarios. In practical application, it is necessary to choose the appropriate protection type according to the specific needs and conditions of the power system to ensure the safe and stable operation of the power system.

3.3. Configuration Principles and Methods of Relay Protection

The configuration principles and methods of relay protection play a vital role in the safe and stable operation of power system. As the "goalkeeper" of power system, the configuration of relay protection must follow a series of strict principles to ensure that it can act quickly and accurately in case of equipment failure or abnormality, isolate the failure and minimize the impact on power system. The configuration of relay protection should first follow the principle of selectivity, that is, when the power system fails, it should be able to selectively remove the failed part without affecting the whole system. This requires that the protection device should have enough sensitivity and selectivity in setting, which can accurately judge the fault location and avoid unnecessary power failure. Swiftness is also one of the important principles of relay protection configuration. After the fault occurs, the protection device should act as soon as possible to remove the fault, so as to reduce the damage to the equipment and the impact on the system. Fast action helps to maintain the stability of the system and prevent the fault from expanding. In addition, reliability is the foundation of relay protection configuration. The protection device must be stable and reliable, not affected by external interference, so as to ensure that it can act reliably when it needs to act, and can not act reliably when it doesn't need to act. This requires that the operating environment and various possible faults should be fully considered in the design and selection of protection devices. In terms of configuration method, relay protection usually adopts multi-level protection configuration, that is, multi-level protection such as main protection, backup protection and auxiliary protection is set. The main protection is responsible for quickly removing the main faults, the backup protection provides protection when the main protection fails, and the auxiliary protection provides additional monitoring and diagnosis functions. This configuration not only ensures the selectivity and rapidity of protection, but also improves the reliability of protection.

The configuration principle and method of relay protection is the key to ensure the safe and stable operation of power system. By following the principles of selectivity, rapidity and reliability, and adopting the method of multi-level protection configuration, the stability and reliability of power system can be greatly improved, which provides a strong guarantee for the long-term development of power system.

4. THE CORRELATION ANALYSIS OF POWER TRANSFORMER ELECTRICAL TEST AND RELAY PROTECTION.

4.1. Interaction between Electrical Test and Relay Protection

There is a close interaction between electrical test and relay protection, which is reflected in many aspects. First of all, electrical test is an important means to evaluate the performance and safety of power transformer, and its result is often directly related to the configuration and parameter setting of relay protection. Electrical tests can find potential faults and hidden dangers inside the transformer, such as winding short circuit, insulation aging, etc. If these faults are not found and treated in time, serious accidents may be caused. Therefore, the results of electrical tests often provide an important reference for relay protection, which helps to determine the sensitivity and action characteristics of the protection device, so as to ensure that the fault current can be cut off in time and accurately when the fault occurs and protect the stable operation of the power system. The performance and reliability of relay protection are also affected by electrical tests. When conducting electrical tests, various performance indexes of transformers, such as insulation resistance and dielectric loss, are usually

tested. These test results can not only reflect the running state of transformer, but also provide basis for relay protection setting. For example, if the electrical test finds that the insulation performance of the transformer is declining, it is necessary to adjust the setting value of the relay protection device to adapt to this change and ensure reliable operation when the insulation fault occurs. In addition, the interaction between electrical test and relay protection is also reflected in mutual verification and cooperation. When conducting electrical tests, it is often necessary to simulate various fault situations to test the action performance of relay protection devices. At the same time, the action results of the relay protection device can also be fed back to the electrical test, providing reference for the analysis and judgment of the test results. This process of mutual verification and coordination is helpful to improve the accuracy and reliability of electrical test and relay protection and ensure the safe and stable operation of power system.

4.2. Application of Electrical Test in Relay Protection Configuration

The application of electrical test in relay protection configuration is the key link to ensure the safe and stable operation of power system. Through electrical test, the performance of power transformer can be comprehensively tested, thus providing accurate data support for relay protection configuration. In electrical test, the application of professional means such as insulation resistance test, dielectric loss tangent test, DC resistance test and variable ratio test can accurately evaluate the running state of transformer. For example, insulation resistance test can detect the insulation performance of transformer and prevent faults caused by insulation aging or damage; The tangent test of dielectric loss angle can reflect the dielectric loss inside the transformer and provide the basis for the setting of relay protection. These test data are not only helpful for parameter setting of relay protection devices, but also provide important reference for rapid fault location and treatment when transformers are abnormal. In relay protection configuration, the results of electrical tests are widely used in the design and optimization of protection schemes. According to the data of electrical test, the action threshold of the protection device can be set accurately, so as to ensure that the protection device can act quickly and accurately when the transformer fails, cut off the fault current and prevent the fault from expanding. At the same time, by comparing the historical electrical test data, the changing trend of transformer performance can be found in time, providing data support for preventive maintenance.

The application of electrical test in relay protection configuration not only improves the safety and reliability of power system, but also provides strong technical support for intelligent management of power system. By deepening the correlation analysis between electrical test and relay protection, we can further optimize the operation and maintenance strategy of power system and ensure the long-term stable operation of power system.

4.3. The Role and Significance of Relay Protection in Electrical Test

In power system, power transformer plays a vital role, and its stable operation is directly related to the safety of the whole power grid. In order to ensure the safety of transformer, electrical test and relay protection are indispensable links. Relay protection device plays multiple roles in electrical test and has far-reaching significance. The relay protection device can monitor the power transformer in real time, and accurately judge the running state of the transformer by collecting key parameters such as current and voltage. In the electrical test, when the transformer has abnormal situation or fault, the relay protection device can react quickly, cut off the fault current and prevent the fault from expanding, thus protecting the transformer from further damage. This ability of quick response greatly improves the stability and reliability of power system. In addition, the relay protection device can also provide rich fault information, help the operation and maintenance personnel to quickly locate the fault point, and provide strong support for the subsequent fault diagnosis and maintenance work. In the electrical test, through in-depth analysis of the fault information recorded by the relay protection device, the fault type and cause can be accurately judged, which provides a scientific basis for the maintenance of the transformer.

The relay protection device plays a vital role in the electrical test of power transformer. It can not only monitor the running state of transformer in real time to ensure the stable operation of power system, but also provide fault information to help operators locate and solve problems quickly. Therefore, in the electrical test of power transformer, we must attach great importance to the configuration and application of relay protection devices, ensure their accuracy and reliability, and provide a solid guarantee for the safe and stable operation of power system.

5. SUMMARY

This paper discusses the relationship between electrical test and relay protection of power transformer and its importance. Firstly, this paper summarizes the research background, significance and research status at home and abroad. Then, the purpose, classification, common methods and techniques of electrical test are expounded in detail, and the analysis and processing of test results are discussed in depth. Then, the basic principle, device classification, configuration principles and methods of relay protection are introduced. On this basis, this paper focuses on the analysis of the relationship between electrical test and relay protection, and discusses their interaction in practical application. The research achievements and shortcomings are summarized, and the future research prospects are put forward. This paper has important guiding significance for ensuring the safe operation of power transformers.

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