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Research on temperature rise test of low voltage reactive power compensation device

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Abstract: *In the temperature rise test of reactive power compensation device of low-voltage switchgear, the temperature rise acquisition module can not bear the rated voltage of switchgear. The design of multiple temperature rise acquisition modules can effectively solve this problem and realize the temperature rise test detection of reactive power compensation device. After the capacitor is fully put into operation, the capacitor input phase-to-phase voltage is the rated voltage of the equipment. During the temperature rise test, it is necessary to measure the temperature rise of the terminal A, B, and C. However, the temperature rise acquisition module cannot withstand a large voltage value. Therefore, multiple modules are designed. The temperature rise acquisition channel of each module only measures the temperature rise of one phase. The capacitor housing also needs to be measured by a separate module to prevent the module from bearing a higher voltage.*

Keywords: *temperature rise test of reactive power compensation device; temperature rise acquisition module; testing*

1. Introduction

Low-voltage reactive power compensation devices are widely used in power systems to reduce line losses and improve power factor and power quality[1]. The low-voltage complete reactive power compensation device is simple and economical, easy to control, and is the most commonly used method of reactive power compensation[2]. The temperature rise test of reactive power compensation device is an important index to measure the quality of products. In the temperature rise test, in order to ensure the accuracy of the test, the three-phase voltage regulator is used for rated voltage input [3].

2. Methods and principles

The temperature rise test of reactive power compensation device for low voltage switchgear is carried out. The power frequency voltage is applied to the power supply inlet end. After the capacitor is put into operation, the test is carried out by adjusting the rated voltage of the switchgear. The temperature rise of each terminal and shell is measured respectively.

2.1 Three-phase voltage regulator power supply

The temperature rise test of reactive power compensation device for low-voltage switchgear is carried out. In order to ensure the accuracy of the test, three-phase voltage regulator is used for rated voltage input[3].

Fig.1 is the schematic diagram of the three-phase voltage source system. Each phase adjusts the voltage separately, and can realize automatic adjustment, and can also adjust the voltage at the same time. The three-phase voltage regulating source is controlled by touch screen, and the test voltage is accurately controlled by PLC. The operation is simple and the test efficiency is improved. The voltage regulation is three-phase synchronous regulation or single-phase independent regulation mode. The regulation mode is electric regulation. Each voltage regulator is equipped with a temperature sensor, which is controlled by PLC. When the power supply temperature is higher than the limit, the ventilation and cooling system is automatically started. However, after the test, it is necessary to enter the initialization mode to prevent the instantaneous start of misoperation.

The rated capacity and rated output voltage of the three-phase voltage regulator are matched with the

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rated input voltage of the single-phase large current transformer, and the rated frequency is 50HZ, which can operate for a long time under the rated voltage and rated current.

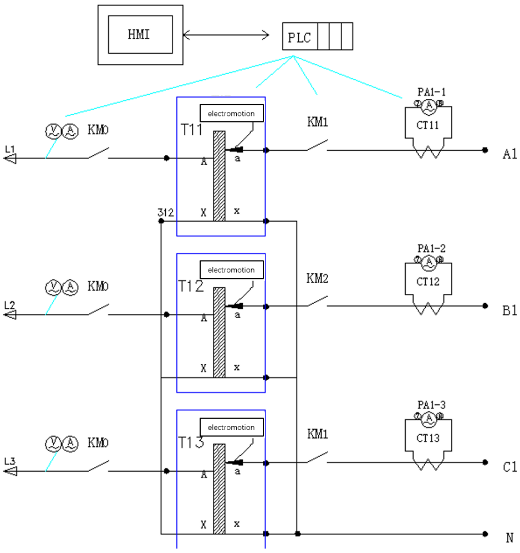

Figure 1: Principle diagram of three-phase voltage regulating source system

2.2 Principle of thermocouple

The temperature rise test of reactive power compensation device of low-voltage switchgear equipment needs to measure the temperature rise by thermocouple. The thermocouple is connected by two different components of the conductor at both ends to form a loop. When the temperature of the joint point is different, the thermoelectric effect phenomenon produces electromotive force (thermoelectric power) in the loop.

The thermocouple uses this principle to measure the temperature. One end directly used to measure the temperature of the medium is called the working end (measuring end), and the other end is called the cold end (compensating end). The cold end is connected with the display instrument or the supporting instrument, and the display instrument will point out the thermoelectric potential generated by the thermocouple.

The thermoelectric potential generated by the thermocouple is used to measure the temperature, which is actually an energy converter that converts thermal energy into electrical energy.

1)The thermoelectric potential of the thermocouple is the difference of the temperature function at both ends of the thermocouple, not the function of the temperature difference at both ends of the thermocouple;

2)When the material of the thermocouple is uniform, the thermoelectric power generated by the thermocouple is independent of the length and diameter of the thermocouple, but only related to the composition of the thermocouple material and the temperature difference between the two ends;

3) When the material composition of the two thermocouple wires of the thermocouple is determined, the size of the thermocouple thermoelectric potential is only related to the temperature difference of the thermocouple;

4)If the temperature of the cold end of the thermocouple remains constant, the thermoelectric potential of the inlet thermocouple is only a single-valued function of the temperature of the working end.

Fig.2 is a thermocouple diagram. Two homogeneous conductors with different components are hot electrodes. The higher temperature end is the working end, and the lower temperature end is the cold end, which is usually at a constant temperature. According to the functional relationship between thermal electromotive force and temperature, a thermocouple scale is made. The graduation table is obtained under the condition that the cold end temperature is 0 °C, and different thermocouples have different graduation tables.

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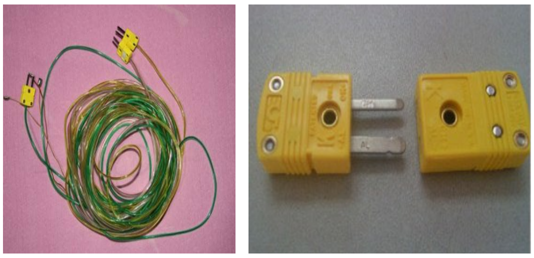

Figure 2: Thermocouple diagram

The thermocouple is divided into K-type or T-type. Table 1 is the parameter difference between T-type and K-type thermocouples. According to the temperature range of the test product, the T-type thermocouple is selected. The installation method is welding embedded paste, through the temperature rise line embedding method can accurately test the temperature change of the acquisition point, and can timely and accurately transmit to the high-speed collector for analysis and control.

Table 1: Parameter difference between T and K thermocouples

model	Thermal electrode materials	temperature range	error range	note
K-joints	Nickel chromium + nickel silicon-	-200~1300°C	±2.5	It has the advantages of good linearity, large thermal electromotive force, high sensitivity, good stability and uniformity, strong oxidation resistance and low price, and can be used in oxidizing inert atmosphere.
T-joints	Pure copper + copper nickel -	-200~350°C	±1.5	It has the advantages of good linearity, large thermoelectric electromotive force, high sensitivity, good stability and uniformity, and low price. The T-type thermocouple is stable and accurate at low temperature.

3. Test analysis

3.1 Test readiness

Fig.3 is the temperature rise test diagram. The rated voltage of the prototype is 400 V. The capacitor is composed of three common compensation capacitors and one sub-compensation capacitor. The rated capacity of the capacitor is 30 Kvar. During the test, the residual current protection circuit breaker is switched off, and the rated voltage is input by the disconnector fuse group.

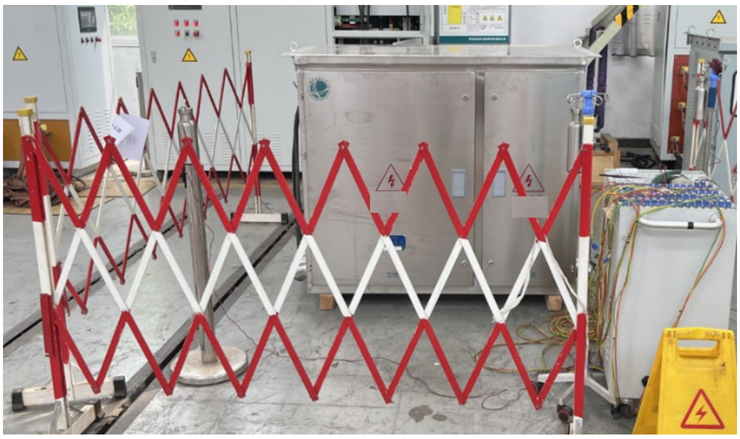

Figure 3: Temperature rise test diagram

The position of the temperature rise measurement point is the inlet and outlet terminals of the compensation circuit molded case circuit breaker, the inlet terminal of the capacitor, and the shell. Since

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the rated voltage of the switching device is 400 V, in order to meet the low voltage requirements of the temperature rise acquisition module, the thermocouple arrangement principle is A, B, and C phases. The positions are located in different modules, and the shell measurement points also need to be detected by independent modules. The temperature rise acquisition system consists of 6 modules, each module consists of 10 channels.

3.2 Test result analysis

The rated voltage of the prototype is applied to 400 V.According to the capacitor operation manual, the confirmation key is pressed immediately after the switch is turned to the left side, and the capacitor is forced to be put into operation. The operation interface is shown in Figure 4, and the output currents in the figure are 140 A, 140.9 A, and 141.5 A, respectively. According to the rated voltage and capacity of the capacitor, the test current is calculated:

$$I_N = \frac{Q}{U_N \times \sqrt{3}} \tag{1}$$

$$I_1 = \frac{I_N \times U_1}{U_N} \tag{2}$$

$$I_2 = \frac{I_N \times U_2}{U_N \times \sqrt{3}} \tag{3}$$

$$I = I_1 + I_2 \tag{4}$$

In formula (1) ~ (4), I_N is the current rated current;

Q is the capacitance capacity;

U_N is the rated voltage of the capacitor;

I_1 three-phase co-compensation test current;

I_2 three-phase compensation test current;

U_1 three-phase co-compensated capacitor rated voltage;

U_2 three-phase shunt capacitor rated voltage.

The test current of A, B and C calculated by formula (1) ~ (4) is 140 A, which is not much different from the actual test current.

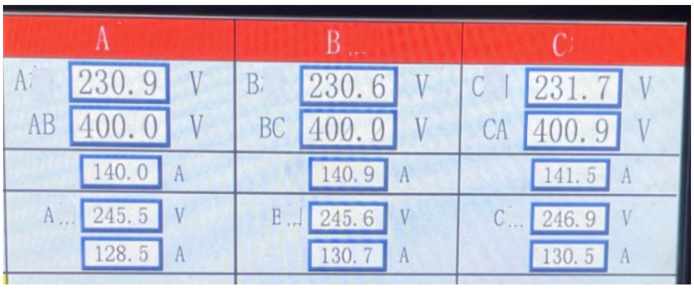

Figure 4: Power operation interface

Table 2 is the test data after the temperature rise of reactive power compensation is stable. The maximum temperature rise in the table is located at the inlet and outlet terminals of the molded case circuit breaker, followed by the temperature rise of the co-compensated capacitor 1, because the distance between the two is the closest; during the test, there is no problem such as the outlet fault of the temperature rise acquisition system, which indicates that it is completely feasible to select the same acquisition module for each phase acquisition position.

Table 2: Is the data after the temperature rise of reactive power compensation is stable

Temperature rise acquisition instrument channel number	Measuring point position	temperature rise value(K)
1	Moulded case circuit breaker incoming lineA	32.2
2	Molded case circuit breaker outletA	34.3

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3	Co-compensated capacitor 1A	31.8
4	Co-compensated capacitor 2A	26.9
5	Co-compensated capacitor 3A	25.1
6	Shunt capacitorA	25.0
11	Moulded case circuit breaker incoming lineB	32.8
12	Molded case circuit breaker outletB	34.6
13	Co-compensated capacitor 1B	30.1
14	Co-compensated capacitor 2B	28.1
15	Co-compensated capacitor 3B	26.9
16	Shunt capacitorB	27.7
21	Moulded case circuit breaker incoming lineC	37.1
22	Molded case circuit breaker outletC	36.5
23	Co-compensated capacitor 1C	27.9
24	Co-compensated capacitor 2C	26.5
25	Co-compensated capacitor 3C	27.7
26	Shunt capacitorC	25.7
31	Co-supplemented capacitor 1 shell	9.7
32	Co-supplemented capacitor 2 shell	12.7
33	Co-supplemented capacitor 3 shell	11.7
34	Sub-compensation capacitor shell	8.0
35	hand lever	12.8

4. Conclusion

In this paper, aiming at the temperature rise test of reactive power compensation device of low voltage switchgear, multiple temperature rise acquisition modules are designed to prevent the damage of high voltage level to the temperature rise test system, and the test is successfully completed to meet the temperature rise test detection ability.

References

[1] Xiaowei Cai. Detection and Analysis of Low Voltage Reactive Power Compensation Device [J]. Manufacturing and Upgrading Today, 2021, (03):60-61.
[2] Manjun Wang. Standard and test analysis of low voltage compensation cabinet [J].Electric drive automation, 2017, 39(02):54-58.
[3] Yuqiang Mou, Zhendong Liu, Yanan Zhang, Jingsi Qin, Yuan Chen.Standard and test analysis of low voltage reactive power compensation device [J].Electric drive,2014,44(01):93-96.