

Analysis and Solution of Condensation Phenomenon in Ring Main Unit

Kexin Shi^{1*}, Junjie Yang¹

¹ Shanghai Dianji University, Shanghai, 201306, China

Abstract. The current condensation phenomenon inside the ring main unit will cause corrosion of components, short circuits, partial discharges and other problems, which will seriously affect the safety and durability of power supply. In response to the above problems, this paper designs and builds a condensation test platform, conducts an experimental analysis on the factors that cause condensation, and combines the conclusions drawn to propose a remote monitoring system for anti-condensation. Operation and maintenance personnel can use a small program to remotely monitor the internal environment of the ring network cabinet and deal with condensation in a timely manner. The application of this system provides great convenience for the operation and maintenance personnel, and also has a significant impact on the monitoring and maintenance of the anti-condensation of the ring network cabinet.

1 Introduction

With the introduction of the smart grid concept and the further increase in the scale of the demand for the distribution network, power companies have higher and higher requirements for the quality of power supply and the reliability of power supply^[1]. An important means to improve the reliability of power supply is to adopt the ring network power supply technology. The ring network power supply can reasonably distribute the electricity load and shorten the power supply distance to ensure the power quality of the user side^[2]. The key equipment of the ring network power supply is the ring network cabinet, which is a combined switchgear, which can combine multi-loop in and out lines, play a role in switching the operation mode of the distribution network, and ensure the power supply safety of the distribution network. It is widely distributed in substations, switch stations, factories and other areas.

Compared with other power equipment, the internal structure of the ring main unit is more complicated. Excessive temperature will generate a lot of water vapor in the closed ring main unit. When the temperature difference between the inside and outside of the cabinet is large, it is easy to cause condensation on the equipment. When the dust and liquid water vapor adhering inside the ring main unit are mixed, a conductive channel will be formed in the cabinet, which will affect the electrical insulation performance of the ring main unit equipment, so that the area that should not be conductive is transformed into an abnormally conductive area. Increased the probability of equipment failure. Once a failure occurs, it will inevitably cause local power supply interruption and even regional power grid paralysis

accidents, causing huge economic losses, so the research on the analysis of the condensation phenomenon of the ring network cabinet and the study of solutions is very important.

2 Analysis of condensation phenomenon

2.1 Factors and hazards affecting condensation

The air under natural conditions is composed of a small amount of dust, water vapor and absolutely dry air^[3], the water vapor that the air can hold is proportional to the ambient temperature, that is, the higher the ambient temperature, the air can hold a greater amount of water vapor^[3], and the so-called dew point temperature refers to the highest temperature at which condensation occurs in the air with a specific humidity, and the water vapor contained in the air at a higher temperature^[3] Due to the sudden temperature change, the water vapor in the air cannot be contained in the cabinet and can only be discharged in the form of liquid water vapor. Under normal circumstances, the moisture in the cable trench at the bottom of the ring network cabinet continues to rise with the passage of the cable room in the cabinet. When the humid air meets the top plate, terminals and other metal components in the cabinet, the surface temperature of the components is relatively high. Low, so that the humid air will be precipitated in the form of liquid water vapor in the collision of cold and heat, and condensation will occur at this time.

Once the condensation of mixed dust attached to the top plate of the cabinet exceeds a certain weight, it will drip on the wiring terminals in the cabinet, forming a

*Corresponding author's e-mail: yangjj@sudj.edu.cn

conductive channel that does not exist originally, causing confusion in logic pulses^[4], leading to electronic components. The probability of failures such as failure and short circuit of the power supply is greatly increased, and it is more likely to cause serious accidents such as fires.

From the above analysis, it can be seen that by destroying the condensation conditions such as temperature difference and humidity, the occurrence of condensation can be eliminated, and destroying any of these conditions can reduce the occurrence of ring network cabinet failures.

2.2 Calculate the dew point value

When the water vapor content in the air is constant and the air pressure is kept constant, the temperature at which the air is cooled to saturation is called dew point temperature, referred to as dew point^[4], which is actually the temperature at which water vapor and water reach an equilibrium state. According to the relevant information, there is a great relationship between the conditions of condensation and the dew point temperature. Therefore, we use the Magnus-Tetens approximation method to obtain the dew point for the next operation. The formula is:

$$T_d = \frac{b \cdot \gamma(T, RH)}{a - \gamma(T, RH)} \quad (1)$$

Among them, T_d is the dew point temperature, T is the temperature, RH is the relative humidity, the constant a is equal to 17.27 degrees Celsius, the constant b is equal to 237.7 degrees Celsius, and γ is:

$$\gamma(T, RH) = \frac{aT}{b+T} + \ln(RH / 100) \quad (2)$$

The dew point temperature is calculated according to the Magnus-Tetens approximation method formula, and the result of the dew point temperature calculation is shown in Figure 1. It can be seen from Figure 1 that when the air temperature in the cabinet does not change, the dew point temperature will continue to approach or exceed the air temperature in the cabinet as the relative humidity in the air in the cabinet continuously increases, and condensation will occur more easily. phenomenon. For example, when the air temperature in the cabinet is 40°C and the relative humidity is 10%RH, the dew point temperature in the cabinet is -1°C, which is much lower than the air temperature in the cabinet, so there is no condensation at this time. When the relative humidity is 70%RH under the same conditions, the dew point temperature in the cabinet is 37.4°C. It can be seen that the condensation phenomenon is caused by a temperature

difference of 2.6°C. In the same way, when the relative humidity in the cabinet does not change, the dew point temperature will continue to approach or exceed the air temperature in the cabinet as the air temperature in the cabinet continuously increases, and condensation is more likely to occur. For example, when the air temperature in the cabinet is 30°C and the relative humidity is 70%RH, the surface dew point temperature of the objects in the cabinet is 26.9°C. When the relative humidity in the cabinet is 60%RH under the same conditions, the dew point temperature in the cabinet is 21.4°C.

Therefore, we conclude that the condensation phenomenon has a great relationship with the dew point temperature. When the dew point temperature is always lower than the temperature in the cabinet, it is not easy to produce condensation.

2.3 Test results

After calculating the dew point temperature in 2.2, the dew point temperature values under different temperatures and humidity are obtained, as shown in Figure 1. It can be seen from the figure that when the air temperature in the cabinet is constant, the dew point temperature will continue to approach or exceed the air temperature in the cabinet as the relative humidity in the air in the cabinet continuously increases, and condensation will occur more easily. For example, when the air temperature in the cabinet is 40°C and the relative humidity is 10%RH, the dew point temperature in the cabinet is -1°C, which is much lower than the air temperature in the cabinet, so there is no condensation at this time. When the relative humidity is 70%RH under the same conditions, the dew point temperature in the cabinet is 37.4°C. It can be seen that the condensation phenomenon is caused by a temperature difference of 2.6°C. In the same way, when the relative humidity in the cabinet does not change, the dew point temperature will continue to approach or exceed the air temperature in the cabinet as the air temperature in the cabinet continuously increases, and condensation is more likely to occur. For example, when the air temperature in the cabinet is 30°C and the relative humidity is 70%RH, the surface dew point temperature of the objects in the cabinet is 26.9°C. When the relative humidity in the cabinet is 60%RH under the same conditions, the dew point temperature in the cabinet is 21.4°C.

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Calculated value of dew point under different relative temperature and humidity

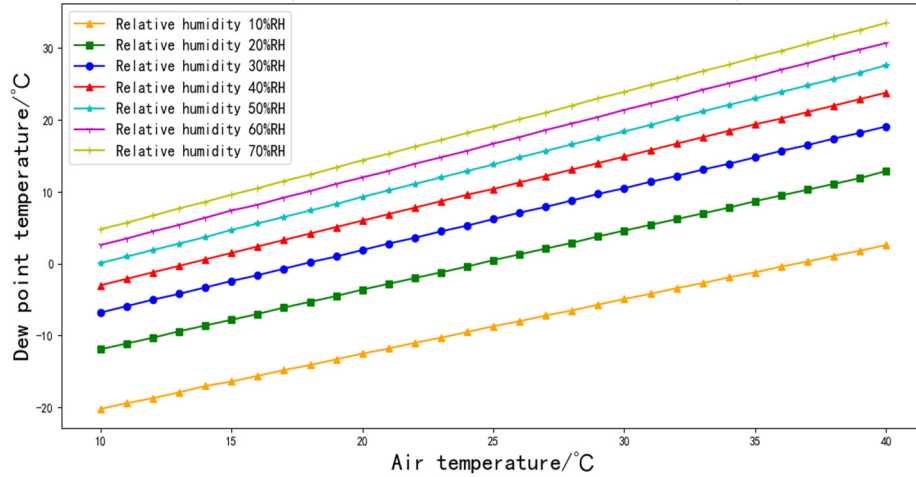


Figure 1 Calculated value of dew point under different relative temperature and humidity

At the same time, refer to related literature [5, 6] and conduct experiments on the length of condensation time under different temperature and humidity conditions. The experiment was carried out when the temperature difference between the inside and outside of the cabinet

was 5°C, 10°C, 20°C, the relative humidity was 70%-90%, and the temperature inside the cabinet was 20°C, 30°C, and 40°C. The experimental results are shown in Figure 2, Figure 3.

Condensation time when the temperature difference between inside and outside of the cabinet is 10°C

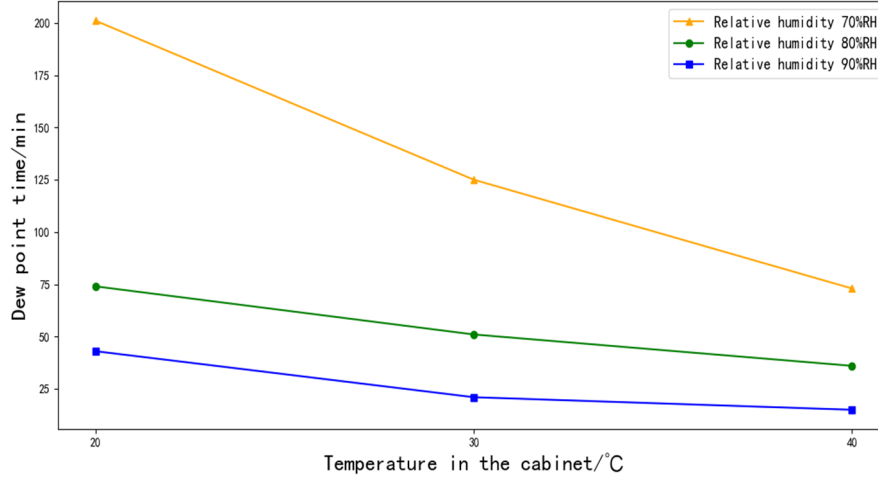


Figure 2 Comparison of condensation time under the same temperature difference between inside and outside the cabinet

Condensation time when relative humidity is 90%RH

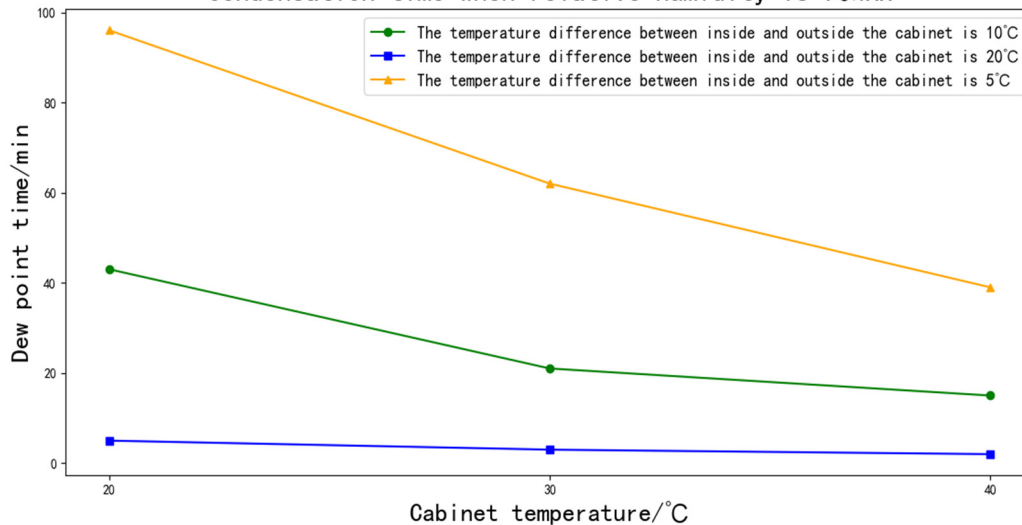


Figure 3 Comparison of condensation time under relative humidity in the same cabinet

2.4 Test summary

Through the design and construction of the temperature and humidity collection and condensation test system, the TH10S-B high-precision temperature and humidity transmitter is used to collect the temperature and humidity in the cabinet and calculate the dew point in the cabinet under different conditions, and record the condensation time under different conditions. The following conclusions are reached:

(1) The most important factor that causes condensation is the dew point temperature. When the air temperature in the cabinet is close to or higher than the dew point temperature, condensation is easy to occur.

(2) Sudden changes in any of the factors such as temperature difference inside and outside the cabinet, relative humidity inside the cabinet, and air temperature inside the cabinet will directly affect the occurrence of condensation. Similarly, the combined influence of the three will also cause condensation. As the temperature and humidity inside the cabinet continue to increase, the temperature difference between inside and outside the cabinet continues to increase, and the time for condensation to occur will become shorter and shorter.

3 Formatting the text

According to the conclusions drawn in Chapter 2, this paper designs and implements the anti-condensation smart applet of the ring network cabinet, which includes three parts: smart hardware terminal, cloud server and client. After collecting various important data running in real-time in the ring network cabinet, the collected data information is analyzed and transmitted to the monitoring center through the 4GDTU communication module to determine the current operating environment status of the ring network cabinet and determine whether there is an abnormality. If the sensor data measured inside the ring network cabinet deviates from the preset threshold of the sensor, an early warning message will be sent through the WeChat applet and operation and maintenance personnel will be arranged for rescue in time.

The modules designed and implemented are as follows:

Homepage map module: The homepage of the applet displays the map of the current area, displays the location information of all the ring network cabinets on the map and can reach the specific ring network cabinet address through the route navigation map.

Data information management module: Display the collected internal temperature and humidity data of the ring network cabinet in this module. Set up the Excel export function, you can save all the collected data in the form of a table locally, which is convenient for future viewing.

Abnormal data management module: Under this module, it is convenient for operation and maintenance personnel to view abnormal information about the ring network cabinet they manage on their mobile phones, such as viewing the internal operation of the ring network cabinet through video, and turning on the

dehumidification device with one button if necessary.

Monitoring management module: Under this module, you can view the video of the abnormal time period online to determine whether a misjudgment has occurred. At the same time, the video download function is set up, and all monitoring videos can be saved locally for easy viewing in the future.

4 Formatting the text

Through the design and construction of the condensation test platform, the TH10S-B high-precision temperature and humidity transmitter is used to collect the temperature and humidity inside the cabinet, and the DHT11 temperature and humidity sensor is used to collect the temperature difference information inside and outside the cabinet. It is concluded that the most important factor for the condensation phenomenon is the dew point. Temperature, when the air temperature in the cabinet is close to or higher than the dew point temperature, condensation is easy to occur. In addition, the temperature and humidity inside the cabinet, and the temperature difference between inside and outside the cabinet, any sudden changes in any of them will affect the generation of condensation. As the temperature and humidity inside the cabinet continue to increase, the temperature difference between inside and outside the cabinet continues to increase, and the time for condensation to occur will become shorter and shorter.

According to the conclusions drawn from the experiment, we designed a remote monitoring system for anti-condensation, using the temperature and humidity information inside and outside the cabinet as the judgment standard, and can remotely monitor the appearance of condensation through the operation and maintenance personnel in the first time, so as to be able to timely Suppress condensation. This system will produce good results for practical applications.

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