Research on improvement of moisture proof technology for JIS control cabinet of 220kV substation based on big data

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Abstract. The outdoor control cabinet of intelligent substation includes the central control cabinet and the intelligent control cabinet. The internal integrated circuits and electronic components are easily affected by the environmental humidity. Through the operation and maintenance data statistics, it is found that the existing heating and dehumidification system in the control cabinet can not fully meet the humidity requirements in the cabinet. In view of this problem, this paper analyzes the factors leading to the increase of humidity in the cabinet, puts forward the research on the improvement of moisture-proof technology of JIS control cabinet in 220kV substation based on big data. In an environment where the air temperature changes rapidly, the test data verify that the moisture-proof technology of JIS control cabinet in 220kV substation based on big data can effectively reduce the humidity in the intelligent control cabinet, and effectively ensure the safe operation of electronic equipment in the intelligent control cabinet.

Key words: big data; substation; JIS control cabinet; moistureproof technology

1. Introduction
The control cabinet in the outdoor control cabinet of intelligent substation is equipped with a large number of secondary wiring terminals, intelligent terminal merging unit and other electronic equipment[1]. The frequent goose chain breaking and other equipment abnormalities in intelligent substation are caused by the abnormal electronic equipment. The safety and reliability of electronic equipment in the equipment area of intelligent substation is becoming more and more important in the operation and inspection of intelligent substation. The air humidity in the intelligent control cabinet has a great impact on the safe operation of the electronic equipment in the cabinet[2]. Therefore, the manufacturers have corresponding moisture driving measures at the beginning of the design. Waterproof and heat exchanger are effective measures to reduce the air humidity in the cabinet. However, with the continuous accumulation of operation time, the sealing performance of the cabinet will decline, and the manufacturer's design is more general and not targeted. The natural environment of different substations is not the same, and the moisture-proof measures related to the cabinet in the specific environment can not fully meet the actual requirements of the site. Some control cabinets still have abnormal phenomena such as condensation. JIS control cabinet of substation is the intermediate
link between outdoor electrical equipment and indoor measurement and control, protection, communication and other equipment. The moisture in JIS control cabinet of substations in Liaoning and other northern regions mainly comes from the moisture in cable trench, and the main time of condensation is in autumn and winter and other seasons with severe temperature changes, which leads to the reduction of insulation resistance of DC secondary circuit to ground, and it is easy to cause protection misoperation or refusal to operate [4-5]. Therefore, effective moisture-proof measures are of great significance to improve the insulation strength and electrical performance of the secondary circuit in JIS control cabinet, prevent the secondary circuit insulation defects and abnormalities, and ensure the safe operation of electrical equipment.

The advantage of modern anti condensation comprehensive technology is to use the big data of substation to comprehensively monitor the temperature, humidity, cabinet door opening and closing, condensation state and other information data of equipment in substation, and calculate and analyze these data to form control strategy, timely control the dehumidification equipment such as exhaust fan, heater and dehumidifier, so as to achieve the optimal dehumidification effect.

The big data of substations include: substation SCADA data, auxiliary system data (site video, cable trench temperature and humidity and water level, cabinet temperature and humidity, cabinet heating plate operating conditions, exhaust fan operating conditions, equipment temperature detection data, etc.), fire detection and alarm system data, electricity meteorological data, geographic data, etc. Therefore, this article takes 220kV substation outdoor control cabinet as the object to study the improvement of 220kV substation JIS control cabinet moisture-proof technology based on big data. Use relevant big data to perform cloud computing, intelligently control the start and stop of the moisture-proof and dehumidification facilities (exhaust fans, heaters, dehumidifiers, etc.) of the control cabinet, and monitor the sealing status of the doors and windows of the control cabinet (prevent rainwater intrusion) and bottom blocking in real time. Sealing conditions (to prevent moisture intrusion in the cable trench) and provide timely warnings and provide repair suggestions. Finally, through data comparison, the effectiveness of the proposed measures is verified, and certain practical experience is provided to ensure the safe operation and maintenance of smart substations.

2. Improvement of moisture proof technology for JIS control cabinet of 220kV substation

2.1 Investigation on Influencing Factors of humidity in outdoor control cabinet of Substation

At present, in order to solve the problem of excessive humidity in high voltage JIS control cabinet, three traditional measures are mainly adopted. One is to install the exhaust fan in the high-voltage switch room to remove the humid air; the other is to install the heater to remove the moisture by heating; the third is to combine the above two methods. With the progress of technology and the improvement of conditions, many substations have undergone unmanned transformation. In the substation, not only the heater can be installed, but also the sensor device can be used to monitor the condensation condition[6]. Once the humidity in the high-voltage JIS control cabinet is close to the condensation condition, the system will automatically start the heater. After the heater is started, the temperature in the high-pressure JIS control cabinet can be increased by increasing the heat, which is conducive to reducing the humidity of the JIS control cabinet. However, this method has obvious lag effect. This is because it takes a long time for the temperature in the high pressure JIS control cabinet to rise after the heater is started. Therefore, this dehumidification method is not very obvious[7]. Especially when the humidity inside and outside the high-voltage JIS control cabinet is very high, once the exhaust fan is started, it will send the high humidity air outside to the inside of the JIS control cabinet, which has the opposite effect. Therefore, it is still an urgent problem to seek an efficient moisture-proof and dehumidification method for substation high-voltage JIS control cabinet protection[8]. At present, using the big data calculation and analysis of the substation, the optimal control strategy of the heater and exhaust fan can solve the disadvantages of the conventional control method.
According to the analysis of the operation of field equipment, one of the main reasons that affect the air humidity in the cabinet is that the rainwater washes the cabinet, resulting in water intrusion into the cabinet body. Even if the sealing strip of the equipment mechanism box and control cabinet in the substation equipment area will be replaced regularly, the waterproof and moisture-proof performance can not be strictly guaranteed. There is no GIS equipment above the intelligent control cabinet in 220kV GIS equipment area of a substation, which is greatly scourd by rain[9]. There is GIS equipment above the intelligent control cabinet in 500kV equipment area, which is much less scourd by rain than the intelligent control cabinet in 220kV equipment area. Taking the intelligent control cabinet of 220kV GIS equipment area and 500kV equipment area as examples, this paper studies the intelligent control cabinet of 220kV GIS equipment area. The station is located in the middle latitude inland, belonging to the warm temperate continental monsoon climate zone. The figure shows the annual precipitation distribution of the station.

![Fig. 1](image1.png)

**Fig. 1** Investigation and analysis of regional humidity

The following figure shows the details of the inner wall fog on the control cabinet door in 220kV equipment area and 220kV equipment area.

![Fig. 2](image2.png)

**Fig. 2** Fog days of control cabinet in equipment area

It can be seen that the fog formation of the intelligent control cabinet in 220kV equipment area is more serious than that of the intelligent control cabinet in 220kV equipment area, which is consistent with the field practice and operation and maintenance experience, that is, the intelligent control cabinet in 220kV equipment area has anti fog protection, which is less affected by rain erosion compared with
the intelligent control cabinet in 220kV equipment area[10]. Air relative humidity (RH%) is the percentage of actual water vapor density (D1) and saturated water vapor density (D2) per unit volume of air at the same temperature. When the relative humidity reaches 100%, it means that the air is saturated at this temperature and the water no longer evaporates. At this point, condensation will occur. The higher the temperature is, the more water vapor can be absorbed, and the higher the corresponding temperature saturated water vapor density D2 is; on the contrary, the lower the temperature is, the less water vapor can be absorbed, and the lower the corresponding temperature saturated water vapor density D2 is. When the actual water vapor density D1 in unit volume air is constant, increasing the air temperature T can reduce the relative humidity RH%. When the air temperature T decreases to the temperature where the actual water vapor density D1 in the unit volume of air is equal to the saturated water vapor density D2, the corresponding air temperature is the dew point temperature TL. This paper puts forward the methods to prevent condensation in JIS control cabinet: first, increase the temperature in JIS control cabinet, so that the temperature of the easily dewed surface is always higher than the ambient temperature; second, seal JIS control cabinet, so as to reduce the water condensation in JIS control cabinet Steam. Under the condition of low temperature "winter" or high air humidity "returning to South", condensation water will form on the top and inner wall of JIS control cabinet in 220kV Xinli substation. On this basis, it is easy to cause the heater in the corresponding local control cabinet can not work due to failure, and the cabinet is affected by moisture and condensation due to continuous rainy weather. Serious condensation and mildew occurred at terminals TB / 54 and 55 of 63qtx low oil pressure blocking trip signal, which led to misoperation of low oil pressure blocking trip relay and signal circuit terminals. The secondary circuit of 220kV JIS switch control cabinet is shown in the figure.

Fig. 3 Secondary circuit diagram of JIS control cabinet

According to the statistical data and comparative analysis, the main reason for the increase of air humidity inside the outdoor control cabinet is rain erosion. How to reduce the water intrusion caused by rainwater erosion has become the main measure to reduce the air humidity in the intelligent control cabinet in rainy season.

2.2 Optimization of substation moistureproof scheme
In order to ensure the moisture-proof and dehumidification effect of high-voltage JIS control cabinet
in substation, the floor of new outdoor control cabinet can be raised or padded up appropriately. Generally, the distance of raising or raising is more than 40cm. This method can effectively reduce the impact of groundwater and water vapor in the cable trench on the high-pressure JIS control cabinet, so as to ensure that the JIS control cabinet works in a relatively dry environment. When the foundation of the power outdoor control cabinet is raised or padded up, the ground of the power outdoor control cabinet is also much dry, which is conducive to reducing air humidity, reducing the occurrence of ozone, and reducing insulation accidents. Operation and maintenance units generally use the installation of dehumidifier and sealed box for moisture-proof treatment, but the moist air in the cable trench under the central control cabinet can continue to rise and flow into the central control cabinet, and the ordinary temperature and humidity controller cannot calculate the relative humidity in real time and avoid the dew point temperature, so it cannot fundamentally solve the problem. According to the climate characteristics of high temperature and high humidity in Summer in Liaoning, the transformation measures are put forward. The cover plate of cable trench is transformed into galvanized iron cover plate with holes to effectively reduce the air humidity in the cable trench. The traditional plugging mud is changed into a plugging material with moisture-proof function. Before the retrofit, because of the installation position and power of the heater, the inner top is prone to condensation, and some wires near the heater are prone to insulation aging due to long-term high temperature. Considering that the moisture in the cable trench in Liaoning and other northern regions is heavier, the disadvantages of using this heater outweigh the advantages, so a condensing dehumidifier is used instead of the heater. The integrated temperature and humidity sensor controller of the condensing dehumidifier can monitor the environment temperature and humidity in real time and limit the working state of the dehumidifier with relative humidity. Dehumidifier can fundamentally solve the problem of high humidity in the box, and the energy consumption is far lower than that of heater. In order to work effectively with the dehumidifier and prevent the external warm and humid air flow from affecting the air humidity in the box, the box should be fully enclosed. The specific transformation scheme is shown in the figure.

**Fig. 4** Transformation scheme of moisture proof and dehumidification system for control cabinet

Add a set of automatic dehumidifier installed at the bottom of the control cabinet (power 65W, original heater power about 390W). A special intelligent control device is designed. By continuously measuring the temperature and humidity of the cabinet and its wall, the relative humidity can be calculated in real time to avoid the dew point temperature and automatically control the start and stop of the dehumidifier. The installation of heater is an effective means for moisture-proof and dehumidification of high-voltage JIS control cabinet in substation. Low temperature is necessary for condensation. Therefore, increasing the temperature of high voltage JIS control cabinet is an effective way to avoid condensation. Through the heater, the temperature in the high-pressure JIS control cabinet can be higher than the external temperature, so the probability of condensation in the JIS
control cabinet will be greatly reduced. In order to realize the intelligent control of the heater, the heater and the temperature sensor can be combined to form the moisture-proof and dehumidification control system of the substation high-voltage JIS control cabinet. The system uses multiple temperature sensors to monitor the internal temperature of high-voltage JIS control cabinet, and uses other temperature sensors to monitor the external temperature of high-voltage JIS control cabinet. When the system detects that the internal temperature of high-pressure JIS control cabinet is 2 ~ 3 ℃ higher than the external temperature, the system can stop the heater. When the temperature difference between the two is less than 2 ~ 3 ℃, the system starts the heater until the temperature in the high-pressure JIS control cabinet is 2 ~ 3 ℃ higher than its external temperature. Besides temperature sensor, humidity sensor can also be installed in high voltage JIS control cabinet of substation. When the humidity sensor detects that the humidity in the high pressure JIS control cabinet exceeds the set value, the system can also start the heater. The adoption of new sensing technology and automation technology is conducive to the realization of moisture-proof and dehumidification intelligent control of high-voltage JIS control cabinet in substation, which can not only achieve the moisture-proof and dehumidification effect of high-voltage JIS control cabinet, but also play the role of energy saving. More importantly, the control system can ensure the safe operation of high-voltage JIS control cabinet in unattended situation, which is an important development direction of moisture-proof and dehumidification of high-voltage JIS control cabinet in Substation in the future.

2.3 Application of new technology and materials in anti condensation of substation control cabinet

At present, more and more anti condensation measures are used, and achieved very good results. For example, the use of liquid flow sealing technology for the "air tight" sealing of the bottom plate of the control cabinet has a very ideal effect on preventing the moisture at the bottom of the cabinet from invading the box. The use of dew proof cotton installed on the top plate of the control cabinet can effectively prevent the condensation on the top of the cabinet, thus preventing the dew drop on the top of the cabinet from falling on the electrical components and causing equipment failure.

Liquid flow sealing technology is a kind of sealing method which uses the material of liquefying flow and then expanding and solidifying. The sealant used is a kind of functional polymer material. Through the design and control of molecular structure, a polymer "chip" is obtained, which can control the flow time and foaming time of the material. In fact, the sealing principle is as follows: first, the liquid is used to seal the plane; the liquid material is immersed in various gaps and holes, then it rises and gels, and at the same time, the sealing system is formed longitudinally by the extrusion force generated during the expansion process, thus achieving the "airtight" sealing effect.

Compared with the traditional cable sealing method, the application of flow sealing technology in the bottom plate sealing of electrical cabinet can effectively block the moisture source and heat source, and prevent the two necessary conditions (humidity and temperature difference) of condensation, so as to achieve the purpose of preventing the formation of condensation to a certain extent.

At present, the most commonly used liquid flow sealing material is BBS anti condensation gas sealing material, which has two components a and B. when using, the two components should be mixed and stirred according to the proportion, generally for a few minutes. The specific time can be selected according to the temperature. The temperature in summer is high, the mixing time is short, and the temperature in winter is low. The mixing time should be appropriately extended to ensure the full fusion of the two materials Together. The evenly mixed liquid plugging material is poured on the bottom plate of the control cabinet like self leveling, so that it can flow fully and finally form a liquid plane. After the liquid is fully expanded, a thicker solid sealing layer is formed, which can completely isolate the moisture of the foundation well or cable trench under the cabinet, and plays a key role in preventing moisture from invading into the cabinet and controlling the air humidity in the cabinet.

Dew proof cotton --- belongs to the field of high molecular materials. It is a composite material composed of cotton like fiber substrate grafted with specific polymer chain segments, with good heat insulation, water absorption, water locking, moisture resistance and durability. It is applied to the top of electric cabinet and communication panel cabinet to prevent condensation on the top plate. In the
The process of mixing, the long-chain polymer and a small amount of weak alkaline organic salt are incorporated into the a-model, which can absorb 600% ~ 700% of the self weight of water. After being separated by chloroprene benzene free universal adhesive, it will not produce corrosion chemical reaction with the cabinet metal. During the mixing process of type B dew proof cotton, the composite hydrophobic material is used as the surface layer, so that water droplets can not easily penetrate into the surface layer, and the fiber skeleton can also store more than 50% of its own weight moisture.

The dew proof cotton is generally installed on the top plate of the control cabinet, which can prevent the condensation of the top plate from forming water drops on the components in the cabinet, and avoid the secondary circuit short circuit fault.

The dew proof cotton has a certain heat insulation ability, which can reduce the temperature difference between the lower surface and the top cabinet, and further weaken the condensation forming conditions. It is also flame retardant, and its use will not increase the risk of fire in the control cabinet.

The installation method of dew proof cotton is simple, one side of which is attached with back glue. During installation, the whole dew proof cotton is cut according to the size and shape of the top plate of the control cabinet, and then the dew proof cotton is pasted onto the top plate of the control cabinet. In order to avoid the weight increase and fall off of the dew proof cotton after absorbing water, a strong magnet can be used for reinforcement.

3. Conclusions
To create a good working environment for high-voltage JIS control cabinet in substation and reduce its internal humidity is an important basis to ensure the normal work and safe operation of JIS control cabinet, and also the basic guarantee for the reliable operation of the whole power system. There are many factors affecting the humidity rise of high voltage JIS control cabinet in substation. In practical work, in order to avoid accidents, we must do a good job of moisture-proof and dehumidification of high-voltage JIS control cabinet. Installation of moisture-proof and dehumidification equipment, effective plugging of cable trench, elevation of ground foundation of new outdoor control cabinet, reservation of sufficient maintenance channel and installation of JIS control cabinet heater are important moisture-proof and dehumidification measures for high-voltage JIS control cabinet in substation. Using big data and new moisture-proof and dehumidification technology (materials) to optimize the moisture-proof measures of JIS control cabinet in 220kV substation can improve the insulation strength and electrical performance of secondary circuit in JIS control cabinet, prevent secondary circuit insulation defects and abnormalities, and ensure the safe operation of electrical equipment. In the future, with the further innovation of technology, the application of sensor technology, automatic control technology and remote monitoring technology will effectively improve the efficiency of moisture-proof and dehumidification of high-voltage JIS control cabinet in substation.

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