Electrical performance analysis of 110 kv GIS terminal extension conducting rod

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Abstract: As GIS terminal is in cooperation with GIS switch, the GIS terminal with 470 mm structure is usually equipped with a 757 mm structure GIS switch. In order to study the influence of the extended conductive pole on the electrical performance of GIS cable terminal, the contact resistance of the extended conductive pole is measured. The measurement results show that the contact resistance meets the requirements of conductive flow. Through finite element simulation calculation of the influence of the extended conducting rod on the GIS terminal electric field distribution, it was found that the maximum field strength of the cable terminal of the extended conducting rod increased by 2 kv/mm, which was smaller than the breakdown field strength of sulfur hexafluoride gas, and the extended conducting rod did not affect the safe and stable operation of the GIS terminal. Extend the conductive rod by finite element simulation calculation interface without air gap and 0.1 mm gap, the distribution of electric field in both cases, contact resistance conforms to the requirements under the premise, extend the conductive rod interface is 0.1 mm gap the maximum field strength of 1.4 kv/mm, less than the sulfur hexafluoride gas breakdown voltage, contact air gap does not affect the safe and stable operation of the GIS terminal.

1 Introduction

IEC 62271 *high voltage switch equipment and control equipment* defined the GIS terminal connected to the switch at the bottom of the flange dimension and high dimension [1], and 110 kv GIS terminal with GIS switch height is divided into 470 mm and 757 mm, which is 470 and 757, but in the cable accessories industry manufacturing plant home, for the most part is to design the product according to the type 470, when cooperate with height is 757 mm[2], usually on the basis of the model 470 a 287 mm conductive extension rod, can meet the requirements. The type test reports of some cable accessory manufacturers were inquired[3]. Some manufacturers only tested and tested the type 470 GIS terminal, but lacked the type 757 height GIS terminal test data. Operational practice, the type 757 and type 470 GIS terminal used more widely, in the feasibility study[4-5], preliminary design review, often questioned 757 type GIS add conductive terminal extension rod for GIS is influential cable storehouse safe and stable operation, due to the increase of conductive belongs to cable accessories manufacturers provide extension rod, GIS manufacturer cannot ensure conductive extension rod meets the demand of GIS cable storehouse safe and stable operation, cable accessories manufacturers provide a type test report is not clear affirmation opinion[6]. Therefore, it is necessary to conduct experimental

analysis and demonstration for the GIS terminal to add conductive extension rod, so as to completely eliminate the security doubts existing in operation and maintenance practice.

2 GIS terminal typical structure

Model 757 GIS terminal has two types of structure. One is a fully prefabricated GIS terminal with a long internal cone, as shown in figure 2. The other is a 287 mm conducting rod added to the 470 GIS terminal. The contact surface of the conducting rod is generally smooth without burrs. See Figure 1 for details. The model 470 GIS terminal is shown in Figure 2.:

Fig.1 Terminal of type 757 GIS

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Fig.2 Terminal of type 470 GIS

3 Test analysis

With extended type 757 GIS terminal of the conductive rod, with 470 type GIS terminal difference is whether there is the extension of 287 mm conductive rod, due to the extension of the conductive rod connected with 470 type GIS terminal by bolts is fixed, the contact resistance performance is measured the key indexes of the conductive pole overall conductivity, and appearance inspection, contact the air gap, conductive pole the insulation of the electric field intensity affect the GIS terminal performance as a whole.

Ocean technology co., LTD., wuhan DM - 5000 model loop resistance tester, can be used in a large current incentives, measurement of conductive rod, contact resistance test schematic diagram, C1 and C2 terminal current loop, P1, P2 terminal voltage circuit, measuring contact resistance showed $2.86 \mu\Omega$, its conductive performance to meet standard requirements.

4 Insulation performance

In order to study the overall insulation performance of the extended conductive rod for the GIS terminal, taking the 630 square millimeter section cable as an example, the overall electric field distribution of the increased extended conductive rod GIS terminal is analyzed. Two situations are considered for comparison. One is the type 757 GIS terminal with the extended conductive rod and the type 757 fully prefabricated GIS terminal with the long internal cone. One is to extend the air gap contact of the conducting rod and to have the air gap contact of 0.1 mm. The electric field distribution under the two conditions is simulated and calculated respectively.

Fig.4 Axisymmetric plane model of GIS terminal

4.1 Modeling

The GIS terminal is modeled in accordance with terminal drawing 1:1, and the difference of field intensity of the conductive part of the two structures is determined through simulation calculation. As the GIS terminal model structure is axisymmetric, the planar axisymmetric structure can be used for modeling. The difference between the type 757 GIS terminal with extended conducting rod and the type 470 GIS terminal is whether there is 287 mm extended conducting rod. Therefore, the electric field distribution at the lower end of the extended conducting rod is 470 GIS terminal electric field distribution when the type 757 GIS terminal with extended conducting rod is simulated. Analysis with extended conductive rod type 757 GIS terminal and the length of the inner cone type 757 total prefabricated GIS terminal epoxy under casing section structure, internal stress of epoxy tube cone is almost the same, considering cable main insulation semi-conduction shielding layer outside the shielding effect, thus to simplify the model, epoxy casing under the cable metal shell can be ignored.

The numerical calculation method of electrostatic field was adopted in the simulation analysis. The boundary conditions were as follows: 64 kv voltage was applied to the conducting rod under power frequency, and 0 potential was applied at infinite distance.

The calculation principle adopts the calculation equation of electrostatic field, as shown in (1) - (4).

$$\nabla \cdot D = \rho \quad (1)$$

$$D = \epsilon E \quad (2)$$

$$\epsilon = \epsilon_0 \epsilon_r \quad (3)$$

$$E = -\nabla \phi \quad (4)$$

Where D is the electric displacement vector, is the charge density, E is the electric field intensity, ϕ is the scalar potential. The full model of GIS terminal is shown in Fig.3. The 1/4 axisymmetric plane model and the grid subdivision model are shown in Fig.4.

Fig.3 GIS terminal full model

4.2 GIS terminal electric field distributions

The terminal potential distribution of GIS type 470 with extended conducting rod and fully prefabricated long internal cone is shown in Fig.5, respectively. It is

obvious from the figure that the potential distribution of the two structures is relatively uniform, with no obvious difference, and the highest potential is concentrated in the conductive part of the metal.

Fig.5 GIS terminal potential distribution (Type 470)

The electric field distribution at the end of GIS of type 470 with extended conducting rod and fully prefabricated long internal cone is shown in Fig.6. It is obvious from the figure that the electric field distribution

of the two structures is relatively uniform without obvious difference. The maximum field strength of the part above the epoxy sleeve is less than 2 kV/mm, and there is no concentration of field strength.

Fig.6 GIS terminal electric field distribution (Type 757)

By comparing the electric field distribution of the two structures, it can be seen that the field intensity of the two structures is evenly distributed and there is no concentration of the field intensity, so the two structures can ensure safe operation.

4.3 Effect of air gap on contact surface

For the type 757 GIS terminal with extended conducting rod, the installation process of the extended conducting rod is not well controlled, and the contact surface may produce air gap, etc. In order to analyze the influence of the contact surface air gap GIS terminal, the field strength of the conductive part of two kinds of extended

rod structures (one with 0.1mm air gap and the other without air gap) is simulated. Since the model structure is axisymmetric, the planar axisymmetric structure is used for modeling. Since the type 757 GIS terminal and the type 470 GIS terminal with an elongated conductive rod are only added with a conductive extension rod, the whole of the type 470 GIS terminal can meet the standard requirements by default. Therefore, only the location where the elongated conductive rod is connected to the metal part of the terminal is considered.

The potential distribution diagram of the conducting rod is shown in Fig.7. It can be seen from the figure that the potential distribution of the two structures is uniform.

Fig.7 Potential distribution of conducting rod

The distribution diagram of the overall field strength of the contact surface of the conducting rod is shown in Fig.8, and the distribution diagram of the local field strength of the contact surface is shown in Fig.9. It can be seen that the maximum field strength at the connection of the extension rod is 1.4 kV/mm, and there is no obvious concentration of field strength. As the

insulation performance of sulfur hexafluoride gas in GIS is about 3 times that of air, its insulation performance is similar to that of transformer oil at 4 atmospheres of pressure, and the electric field intensity of 1.4 kV/mm is far less than the breakdown field strength of sulfur hexafluoride gas.

Fig.8 Electric field distribution of conducting rod

Fig.9 Local field strength of contact surface

5 Conclusion

Through experiments, the electrical performance of the two cases is calculated. The type 757 GIS terminal formed by adding a 287 mm conducting rod to the 470 GIS terminal, and the contact resistance, electric field distribution and other electrical performance meet the requirements of the safe and stable operation of the GIS terminal. When the increased contact resistance of the extended conducting rod meets the requirements, the small air gap does not affect the electric field distribution of the conducting rod.

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