Pisco Med Publishing

Original Research Article

Study on the Application of 220/20kV SF6 Gas Transformer

Jun Zhou[1], Weidong Chen[1*], Haoxi Tu[2], Lianfeng Wang[1], Hongmei Ni[1]

[1] Shenzhen Power Supply Planning and Design Institute Co., Ltd., Shenzhen, Guangdong Province 518054, China. E-mail: cwd1789@163.com

[2] Shenzhen Power Supply Bureau Co., Ltd., Shenzhen, Guangdong Province 518000, China

Abstract: With the rapid development of Shenzhen's economy, the land resources in Shenzhen are more and more scarce, and the location of substation is more and more difficult. In order to solve the contradiction between the land resources shortage and the development of power grid, the new mode of substation construction of "embedded attached substation" came into being. Because of the particularity of the embedded attached substation, the fire protection requires that the equipment of this kind of substation should be oil-free, making it difficult to select the appropriate 220/20kV transformer. Therefore, this paper studies a new 220/20kV SF6 gas transformer for the above problems, combined with its structural characteristics, aspects including fire protection, ventilation and noise reduction are described to provide reference for transformer selection of this type of substation.

Keywords: Embedded Auxiliary Substation; SF6 Gas Transformer; Fire Protection; Ventilation; Noise Reduction

1. Introduction

The power grid construction of Qianhai cooperation zone in Shenzhen is mainly based on 220/20kV voltage level, and due to the limitation of land resources, several embedded auxiliary substations with 220/20kV voltage level are planned. As this type of substation requires oil-free equipment, the selection of safe and reliable transformers becomes the construction bottleneck of this kind of substation. This paper studies a new type of 220/20kV substation SF6 gas transformer, and carries out in-depth study on its structural characteristics, layout, fire protection, ventilation and noise reduction.

2. Structural characteristics of the transformer

2.1 Cooling system

When sulfur hexafluoride gas is used as cooling medium, whose density is only about 1/60 of transformer oil (when the gas pressure is 0.22mpa), its convection heat transfer coefficient is one order of magnitude smaller than that of transformer oil, which not only causes the difficulty of heat dissipation of gas transformer, but also causes the longitudinal uneven distribution of winding temperature rise. In order to meet the cooling characteristics, not only the chip radiator and fan are set in the gas transformer, but also the air pump is added to carry out the gas power circulation. The circulation rate of the gas transformer is dozens of times higher than that of the forced oil-cooled oil immersed transformer. The circulation rate of each air pump is 20-40 cubic meters per minute, and two or more air pumps are usually used for each transformer. Generally, when the load rate of the main transformer exceeds 30%,

doi: 10.18282/fme.v2i1.805

the air pump shall be put into operation to increase the heat dissipation effect.

2.2 Insulation structure

Transformer insulation consists of turn to turn insulation, winding end insulation, main insulation and external insulation. PET film is used as insulation cloth of copper wire for gas transformer. The maximum allowable temperature of oil immersed insulating paper is 105 ℃, while the plastic film can withstand 120 or 130 ℃, so the coil in gas transformer can withstand higher ambient temperature than that in oil immersed transformer.

3. Fire protection of the transformer

The internal insulation medium of gas transformer is SF6 gas, which is inert gas without combustibility. After the insulation damage of the gas transformer causes short circuit, the internal temperature rises sharply and produces arc, which only leads to the temperature rise of internal SF6 gas and does not produce combustible medium. At the same time, the increase level of internal pressure caused by gas temperature is far less than that of oil immersed transformer. It can be seen that the gas transformer will not explode generally without pressure release device deep fried. Even if the increasing temperature of the gas transformer causes the box to burst, the SF6 gas ejected will not burn to cause fire. However, a small amount of other materials inside the transformer box have been basically carbonized under high temperature due to the isolation of the SF6 gas and before the SF6 gas is exhausted and contacted with the air, there will be no fire.

It indicates that SF6 gas transformer will not generate fire caused by combustion, so no special fire extinguishing system is required.

4. Ventilation of the transformer

4.1 Heat dissipation and ventilation

4.1.1 Local arrangement of cooling device

When this arrangement is adopted, all heat generated by losses of the transformer is released in the transformer room, which includes no-load loss and load loss of the transformer. Taking 220/20kV transformer with rated capacity of 75mva as an example, its total loss rating is about 299kw (54kw of no-load loss and 245kw of load loss). Under the meteorological conditions of Shenzhen, when the indoor exhaust temperature is 40 ℃, its calculated ventilation capacity needs 11.5 × 104 m^3/h. Large ventilation volume needs to be equipped with large air exhaust fan, with considering its power consumption and noise problems.

4.1.2 Separate arrangement of cooling device

In this way, the cooling device is generally arranged in the open air, and its heat dissipation is transmitted through the natural air without mechanical heat dissipation. The transformer body is placed indoors. At this time, the body will still generate some heat, which needs to be discharged to the outdoor through mechanical ventilation. According to the investigation and research of oil immersed transformer, the heat dissipation of oil immersed transformer body accounts for about 5%-10% of the total loss of transformer. According to this standard, the indoor ventilation capacity of SF6 gas transformer body is about 1.0 × 104 m^3/h, which is far less than the layout plan of the same room, and the energy consumption and noise of ventilator will be significantly improved.

4.2 Emergency ventilation

The technical code for design of 220kV ~ 750kV substation requires that the emergency exhaust air volume in the distribution unit room shall not be less than 12 times/h. The fire risk of SF6 transformer room is relatively low, and the space of transformer room is large. At the same time, 220kV substations are mostly unattended, and the emergency ventilation system is mostly post accident ventilation. Therefore, it is suggested to set post accident ventilation system according to SF6 electrical equipment room. In addition, the ventilation system shall be linked with SF6 gas monitoring system. When SF6 gas leakage is detected, the ventilation system shall be started in time. The air vent of the emergency ventilation system for SF6 transformer shall be set in the place where there is seldom anyone staying or passing; the air vent shall not face the outdoor aerodynamic shadow area and positive pressure area.

5. Noise reduction measures

5.1 Noise reduction measures of transformer equipment

The noise reduction measures should start from the equipment body to reduce its noise value, which is mainly affected by the current production technology level and cost. In the production of transformer, using high quality silicon steel material and reducing the magnetic density of the main transformer core are conducive to reducing the transformer body noise.

The cooling device is also affected by the production technology level and material characteristics. From the point of view of noise reduction, the noise level will be effectively controlled by using self cooling transformer and cooling device without cooling fan. However, at present, because the cooling effect of air transformer is not as good as that of oil immersed transformer, forced air cooling is often used. At this time, the noise effect of cooling fan needs to be considered. The fan with low speed, low air pressure and large air volume can effectively reduce the noise of cooling equipment.

5.2 Noise reduction of transformer arrangement

The indoor arrangement of transformer is one of the effective measures to reduce the noise of transformer. After the transformer is arranged indoors, the sound insulation of the wall can effectively reduce the noise of the transformer, but it is necessary to pay attention to the optimization of ventilation, heat dissipation and noise reduction.

a) Local arrangement of cooling device. When this arrangement is adopted, the noise of transformer body and radiator can be effectively controlled due to the effect of wall sound insulation. However, cooling and noise reduction is a major contradiction in the design of transformer room. Under this condition, the transformer room needs a large number of air inlet, and it is necessary to open large air inlet louvers and other facilities to make the noise in the transformer room leak. At this time, the noise can be controlled by setting special ventilation channels and adding partition walls at different positions. In addition, the heat dissipation and ventilation capacity of the transformer is very large, which requires a large ventilation system to effectively eliminate the indoor heat. The problem is that the noise of the ventilation system is very large, which needs to be controlled. The better way is to set up a special ventilation fan room to place the fan, and the air outlet of the fan is equipped with a muffler.

b) Separate arrangement of cooling. When this arrangement is adopted, the transformer body is set indoors and the cooling device is set outdoors. At this time, the noise of the transformer body is well controlled. Due to the small heat dissipation of the body and the relatively small air inlet, the noise leakage is small. However, it is necessary to pay attention to the setting of the air inlet, which can be provided with silencing louvers, *etc*. The noise of the cooling equipment mainly comes from the cooling fan. It is strictly required to select the type of cooling fan with large air volume and low air pressure, and effectively reduce the fan noise. In addition, according to the building layout, the cooling equipment can be arranged far away from the building noise sensitive area, and appropriate sound insulation wall measures can be set to reduce the noise impact.

Based on the above analysis, it is recommended to set the cooling device separately when it is permitted.

5.3 Ventilation system noise

When the transformer is arranged indoors, the noise of its ventilation system can not be ignored, sometimes even exceeds the noise of the transformer. The main noise reduction measures are as follows: adopt low-noise fan, that is trying to select low-speed fan under the condition of meeting the wind pressure; set fan room, that is setting effective muffler at the air outlet of fan; control the air speed at the air outlet. Through the above measures, the fan noise is controlled within the required noise range.

6. Conclusion

To sum up, combined with the structural characteristics, fire protection, ventilation and noise reduction of 220/20kV SF6 gas transformer, it can be applied to the embedded auxiliary substation, and provide reference for the embedded auxiliary substation in equipment selection.

References

1. Code for fire protection design of thermal power plants and substations (GB 50229-2006). Available from: https://max.book118.com/html/2017/0119/85236480.shtm.
2. Shenzhen Power Supply Bureau Co., Ltd. Research report on auxiliary substation.
3. Shenzhen Power Supply Planning and Design Institute Co., Ltd. Preliminary design report of 220kV Guiwan No. 3 transformer station. 2020.