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Research on Cabin Integrated Equipment Based on Gis

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Abstract: Through the research on the principle of GIS gas insulated switchgear, a GIS-based cabin integrated equipment method is proposed. The insulation characteristics and engineering calculations of SF6 gas are analyzed, which provides a basis for the selection of 220kV and 110kV equipment. Analyzed the applicability of 220kV equipment selection of HGIS equipment and GIS equipment in modular substations. At the same time, it compared the floor area and other indicators, and finally decided to adopt the GIS plan, further optimize the product structure and layout, and improve space utilization It can reduce the equipment footprint and make the layout of the power distribution device more compact. Through the comparison and analysis of the main wiring types of the 110kV single bus three section and double bus wiring, it is found that there are three aspects of reliability, flexibility and economy. Single-bus three-section is better than double-bus wiring, so 110kV is determined to adopt single-bus three-section wiring. Under the premise of meeting the requirements for power supply safety, reliability, and flexibility, 110kV electrical main wiring is optimized to achieve The purpose of simplifying operation and maintenance procedures and saving investment.

1. Introduction

With the rapid development of economy, the scale of power grid construction is becoming larger and larger, and the number of high-voltage product cabinets is increasing year by year. The use of cabinet type gas insulated metal enclosed switchgear is also gradually increasing. It is a high-tech product formed by the expansion of high-voltage products to medium voltage field. It installs high-voltage components such as circuit breaker, disconnector and grounding switch in the sealed metal cabinet, and fills low-pressure gas (mainly gas or its mixed gas at present) as the insulating medium.With cable terminal as the in and out line, it has gradually developed into one of the important varieties of metal enclosed switchgear[1-4].

The national development and Reform Commission clearly pointed out that the “new infrastructure” includes the construction of information infrastructure, integration infrastructure and innovation infrastructure. Combined with the national “new infrastructure” strategy (integrated infrastructure), the new generation information technology is adopted to enable the equipment in the substation, so as to realize the modularization, digitization, intellectualization and networking of the

substation. Simplify the construction and installation process of the substation construction stage, improve the reliability of the whole life cycle of the substation in the operation and maintenance process, and provide internal power for promoting the transformation of substation construction to modular construction, promoting the transformation and upgrading of power grid infrastructure, and cultivating new business forms of power manufacturing[5-8].This paper presents a method of integrated cabin equipment based on GIS. This paper analyzes the applicability of HGIS equipment and GIS equipment of 220kV equipment selection in modular substation, and compares the land occupation and other indicators. Finally, the GIS scheme is adopted to further optimize the product structure and layout, improve the space utilization rate, reduce the land occupation of equipment, and make the layout of distribution equipment more compact Through the comparison and analysis of the main connection type, it is found that the single bus three section connection is better than the double bus connection in reliability, flexibility and economy. Therefore, the single bus three section connection mode is determined for 110kV. On the premise of meeting the requirements of power supply safety, reliability and flexibility, the 110kV electrical main connection is optimized to simplify the operation process of operation and maintenance The purpose of saving investment.

2. Principle of Gis Gas Insulated Switchgear

2.1 Insulation Characteristics of Sf_6 Gas

The degree of inhomogeneity in the electric field will have a great influence on the insulation characteristics of gas. In the design of high voltage insulation parts, it is necessary to fully consider the allowable electric field strength of the surface, interior, electrode surface or gas gap of the insulation parts, and the determination of the insulation gap distance is also based on them. In the design of gas filled cabinet, the insulation characteristics of SF_6 gas gap and the surface discharge characteristics of solid insulating parts in SF_6 gas should be fully considered, which are very important for the design of insulation structure of gas filled cabinet. According to Thomson discharge theory, when the gas and electrode material are fixed, the discharge voltage of the gap is a function of the product of the air pressure P and the gap distance[9], that is,$U_F=f(p,d)$.

This law is summarized by Basson in continuous experiments, which is called Basson's law. In a uniform electric field, SF_6 gas has a good insulation performance. The increase of SF_6 gas gap and gas pressure P can effectively improve the insulation capacity of the gap. Within a certain range of P value, the discharge characteristics of SF_6 gas gap conform to Basson's law. In uniform electric field, the breakdown field strength of SF_6 gas gap is about three times that of the same air gap. In the actual structure of SF_6 Electrical apparatus, uniform electric field does not exist. Now some designs generally have some uneven electric field, and the breakdown voltage of SF_6 gas gap will be three times lower than that of air. With the increase of electric field inhomogeneity, the difference between the breakdown voltage of SF_6 gas gap and that of air gap decreases gradually, and even the 50% discharge voltage of SF_6 gas gap is lower than that of air gap. In addition, with the increase of electrode distance, the increase of breakdown voltage will slow down and saturation phenomenon will appear in slightly uneven electric field.

There are many factors that affect the breakdown voltage, such as gas pressure, voltage waveform and polarity, gap distance, electric field non-uniformity, electrode surface roughness, electrode material and electrode area, etc. In SF_6 apparatus, the influence of electric field inhomogeneity on the breakdown voltage of SF_6 gas gap is much greater than that of air. It is more important to improve the distribution of electric field than to increase the gas gap alone.Partial discharge is more likely to develop into gap penetration. In the non-uniform electric field, the initial partial discharge voltage of SF_6 gas gap is very close to the gap breakdown voltage, while the initial partial discharge voltage of air gap is much lower than the gap breakdown voltage under the same

conditions, so the insulation performance of gas gap may be close to or even lower than that of air gap in the non-uniform electric field. According to this characteristic, when designing the insulation structure of C-GIS, the maximum field strength under the test voltage should be lower than the initial partial discharge voltage, so as to ensure that the product can successfully pass the withstand voltage specified in the type test.

SF_6 gas insulation has polarity effect. In SF_6 uniform electric field, because the electric field distribution of the two electrodes is completely symmetrical, there is no polarity effect, that is, the breakdown voltage is the same when the positive or negative voltage is applied. The breakdown voltage of negative electrode is higher than that of positive electrode in non-uniform and extremely non-uniform electric field. In slightly uneven electric field, the negative breakdown voltage is generally lower than the positive breakdown voltage, and the impulse withstand voltage insulation level of C-GIS products is usually determined by the negative breakdown voltage. SF_6 gas insulation has the effect of electrode surface state. The corona inception voltage of the electrode in SF_6 gas is mainly affected by the shape and roughness of the electrode surface, followed by the electrode distance. The increase of the surface roughness and the decrease of the curvature radius of the convex part will lead to the decrease of the gap breakdown voltage. In addition, the conductive particles attached to the surface of the electrode increase the surface roughness of the electrode, and also reduce the breakdown voltage. It is generally believed that conductive particles have a great influence on power frequency withstand voltage, but have little influence on impulse breakdown voltage

2.2 Engineering Calculation of Sf_6 Gas Insulation

The electric field in GIS switchgear is mainly slightly uneven. In the slightly inhomogeneous electric field structure, when the maximum electric field strength in the SF_6 gap reaches a certain value EB, the gap breakdown voltage is as follows:

$$U_b = \eta \times E_b \times d$$

Where:

U_b is breakdown voltage, kV;

ηis insulation utilization coefficient; d is SF_6 gap distance, cm;

E_b is engineering breakdown strength, which can be roughly calculated according to the engineering breakdown strength in Table 1

Tab.1 SF_6 gas gap engineering breakdown strength (P is absolute pressure, MPa)

Voltage form	50 Hz power frequency voltage	Lightning impulse voltage
E_b/kV▪cm^{-1}	$65(10p)^{0.73}$	$75(10p)^{0.75}$

3. Research on 2gis Cabin Layout

3.1 Research on 220 Kv Equipment Selection

HGIS equipment can be maintained and expanded without power cut in a single interval, and the equipment is not limited by the manufacturer, which is in line with the modular design concept. However, its bus is exposed and its layout form is limited, which makes it occupy a large area. It is often used in outdoor layout, and the flexibility of plane layout is worse than GIS. GIS equipment will seal all live equipment and bus, with the characteristics of miniaturization and diversification of bus direction. Indoor and outdoor layout can be selected according to the site conditions to meet the demand of multi-directional outgoing line. The site size and shape can be matched with other distribution equipment sites according to the engineering characteristics, and the layout scheme has high flexibility.

According to the single-layer outgoing line, take three main transformer incoming lines and eight outgoing lines as an example. The layout scheme of GIS and HGIS power distribution device is shown in the figure below.

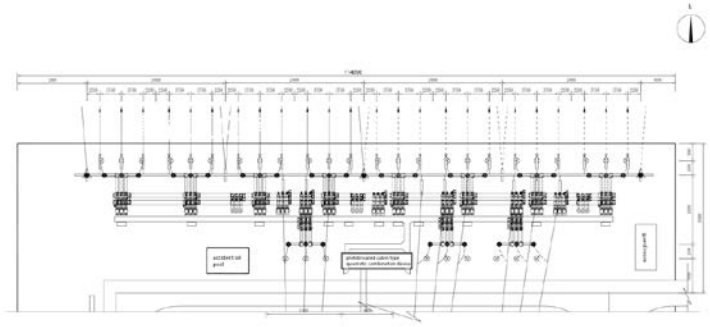

Fig.1 Typical Layout of 220kv Gis Power Distribution Device

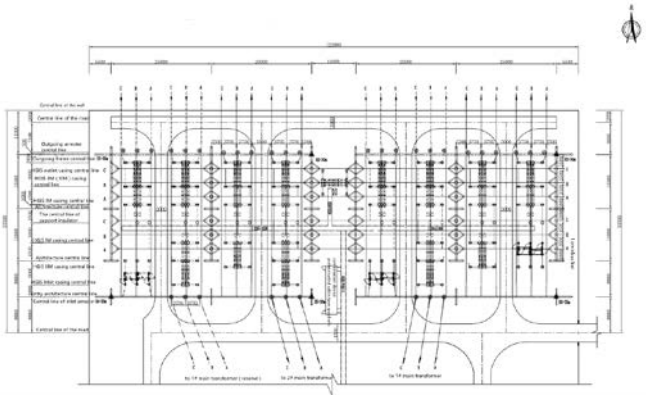

Fig.2 Typical Layout of 220kv Hgis Power Distribution Device

Using GIS scheme, the area of 220kV site is 2964m2; using HGIS scheme, the area of 220kV site is 6771m2. Through the analysis of the above two types of power distribution device, under the same scale condition, GIS power distribution device occupies 3807m2 less than HGIS power distribution device, only 43.8% of HGIS power distribution device, which can greatly reduce the floor area.

3.2 Research on 110 Kv Equipment Selection

This paper makes a comparative analysis of 110kV GIS main connection lines, mainly from three aspects of reliability, flexibility and economy.

(1)Reliability: at present, the reliability of GIS equipment is higher and higher, and the equipment out of operation caused by maintenance and failure is less. Single bus three section connection, two main transformers are respectively connected to two bus sections, and one main transformer is connected to two bus sections. The connection is simple and clear, with continuity index and adequacy index very close to double bus connection, and its reliability is consistent with double bus connection.(2)Flexibility: through optimizing the layout of power distribution device, the same circuit is connected to different sections of bus respectively, so that there are two power supply points for 110kV load. When one section of bus fails or is overhauled, continuous power supply can be ensured. In terms of expansion convenience, single bus three section connection is better than double bus connection. Considering the overall flexibility, single bus three section

connection is slightly higher than double bus connection.(3)Economy: compared with double bus connection, single bus three section connection can reduce 14 sets of bus disconnectors (considering 14 outgoing lines) and save a total investment of 710000 yuan. Moreover, the secondary circuit of single bus three section connection is simple and the investment of secondary equipment is small. Therefore, the economy of single bus three section is better than that of double bus connection.

Tab.2 Equipment investment comparison of two alternative 110kV wiring schemes

Equipment name	Unit	Scheme 1 double bus connection	Scheme 2 single bus three section connection	Unit price (10000 yuan)
110kV circuit breaker (including current transformer)	Platform	18	19	20
110kV disconnector	Group	51	39	6
110kV bus equipment	Platform	6	9	2
110kV grounding switch	Group	51	56	3
Main bus	m	44	24	2
Total	Ten thousand yuan	919	848	-71

4. Experimental Results and Analysis

4.1 Experimental Results and Analysis of 220kv Gis and Hgis

According to the investigation, the minimum interval width of 220kV GIS cable outlet scheme can be reduced to 1.5m (Siemens, GE), abb interval width is 1.65m, and 1 ~ 2 intervals can be arranged in each cabin. Subject to the double bus layout, the height of the bus exceeds 3M. The Siemens scheme is as follows:

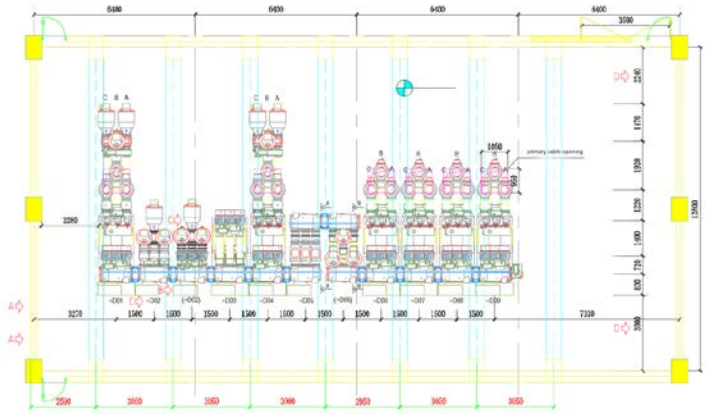

Fig.3 Plane Layout of 220kv Gis Cabin

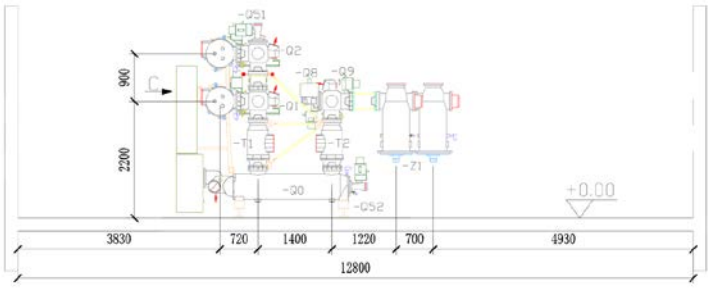

Fig.4 Cross Section of 220kv Gis Cable Outgoing Interval

The station breaks through the common equipment, selects 220kV GIS miniaturized equipment module, and cooperates with manufacturers to further optimize the product structure and layout, improve the space utilization rate, reduce the equipment occupation, and make the distribution device layout more compact.

4.2 110Kv Test Results and Analysis

110kV GIS module: the 110kV side of the station is planned to adopt the single bus three section connection mode, with the main transformer as the core module, each main transformer is equipped with a section of bus at 110kV side, and each section of bus is connected through the section breaker. 110kV GIS adopts cabin type equipment, adopts cable incoming and outgoing lines, prefabricates one installation unit at 2 ~ 3 intervals in the cabin, and transports it to the site for docking and assembly of the cabin and bus.

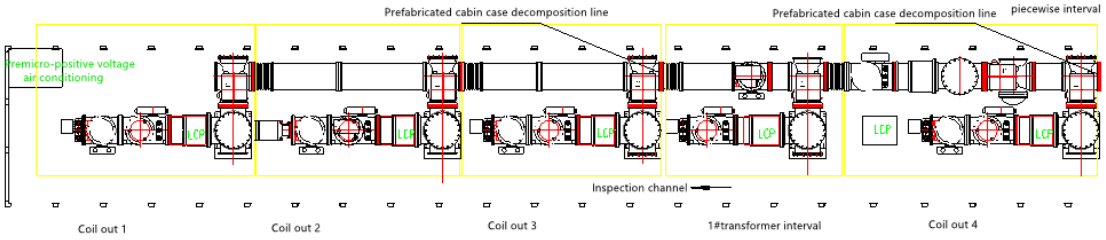

Fig.5 Standard Module of Three Sections of 110kv Single Bus

The 110kV substation adopts single bus three section connection. On the premise of meeting the requirements of power supply safety, reliability and flexibility, the 110kV main electrical connection is optimized and simplified, so as to simplify the operation process of operation and maintenance and save investment.

5. Conclusion

A method of integrated cabin equipment based on GIS is proposed. This paper analyzes the applicability of HGIS equipment and GIS equipment in modular substation, and compares the land occupation and other indicators. Finally, the selection of 220kV equipment is GIS scheme, which further optimizes the product structure and layout, improves the space utilization, reduces the land occupation of equipment, and makes the layout of distribution equipment more compact Through the comparative analysis of the main connection type of double bus connection, it is found that the single bus three section connection is better than the double bus connection in reliability, flexibility and economy. Therefore, the single bus three section connection mode is determined for 110kV. On the premise of meeting the requirements of power supply safety, reliability and flexibility, the

110kV electrical main connection is optimized to simplify the operation and maintenance The purpose is to improve the process and save investment.

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