Preliminary Design of Electric Part of Thermoelectric Unit in a Power Plant

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Abstract：With the rapid development of society, people's awareness of environmental protection continues to strengthen, countries also pay more and more attention to environmental protection, whether from the national policy or from the green development of enterprises in the future, the improvement of power plant operation efficiency is imperative. Among them, improving the operation efficiency of thermal power plants is the top priority, and it is also an important link of national economic transformation. The design of electrical part is an important part of improving the operation efficiency of thermal power plants. 2x300MW thermal power plant is designed, including the power plant electrical main wiring design, plant power design, the main circuit of the power plant short circuit calculation, and it choose the electrical stability and thermal stability of the better electrical equipment. The short circuit calculation of the main circuit of the power plant is carried out and preliminary planning of the secondary circuit scheme is made. A power plant with higher operating efficiency is designed. While improving the operation and economic efficiency of the power plant, it also ensures the reliability, stability and economy of the power plant.

Keywords: Electrical part; Thermal power plant; Short-circuit calculation; Electrical equipment selection

1 Introduction

Electric energy is an important factor in the development of national economy. With the continuous rise of China's economic level and the rapid development of the power industry, the importance of power plants has become increasingly prominent. As the core part of the power plant, the electrical part plays a decisive role in ensuring the stable operation of the power plant and the efficient production of electric energy. Therefore, it is of great practical significance to carry out the research and design of electrical part of power plan. At the same time, in the global warming, thermal power generation emissions of carbon dioxide accounts for the highest proportion. Therefore, improving the energy conversion efficiency and implementing "green" power generation is the inevitable trend of the development of thermal power plants. Therefore, small power plants with large resource loss are gradually being replaced by large and medium-sized power plants and supercritical thermal generating units with higher energy conversion efficiency.

The purpose of this study is to carry out reliability and normative design for the electrical part of 2×300MW thermal power plant, the design of main electrical wiring and plant power design, and then through the short-circuit current calculation, reasonable selection and verification of primary equipment and bus conductor, the purpose of low carbon and reliable will be achieved, which not only meets the needs of China's green development, but also improves the operating efficiency, stability and safety of the power plant, so as to meet the needs of social and economic development for power resources, as well as the strategic needs of China's energy development.

2 Main electrical wiring design

The main electrical wiring is the basis of the entire power system, and the layout of the distribution device, secondary wiring and relay protection are affected by it. Therefore, as the core of the electrical part of the power plant, the electrical main wiring determines whether the entire power plant and power system can operate safely, and whether it is economical and flexible while operating safely. Therefore, it is essential to fully demonstrate the design of the electrical main wiring, which must be compared with the technology and economy, and consider the influence of various factors comprehensively, so as to get the best results in the actual project

According to the design requirements, the single generator capacity should be 300MW, rated voltage of 20KV. Therefore, the model QFSN-300-2 generator is

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selected for both G1 and G2 in this design. The main transformers connected with two 300MW engine sets are of the same model, and the capacity of each is as follows:

$$S_N = \frac{P_N}{\cos\phi} \times 110\% \times (1 - 8\%) = \frac{300}{0.85} \times 110\% \times (1 - 8\%) = 357.18MVA \quad (1)$$

Therefore, choose the model of SFP-10 360,000/220 three-phase double winding booster transformer, its rated capacity is 360 MV·A. The main wiring part of the power plant uses a half circuit breaker wiring, 3 back 330KV outlet, 2 back into the generator line, 1 back to the backup transformer, a total of 6 loops In the perspectives of reliability, flexibility or economy they are the best choices. Among them, the main transformer and the generator set adopt the generator double winding transformer unit wiring method. Because the power of the generator set is 300MW, adopts the closed bus bar with separate phase, no isolation switch is installed, but there is a detachable connection point. The design schematic diagram of the main wiring is shown in Figure 1.

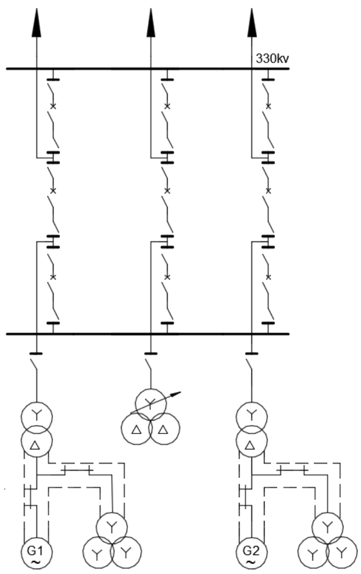
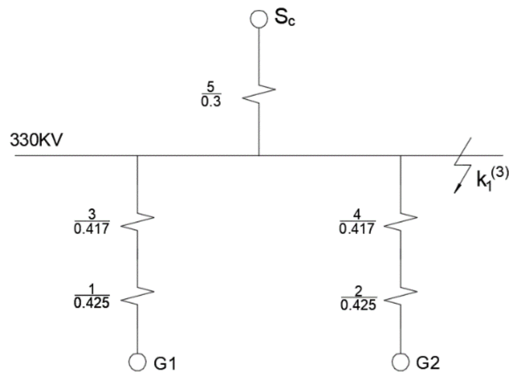


Fig. 1. Schematic diagram of main wiring

3 Design of Plant Electricity

In the plant power wiring of the power plant, unit wiring is adopted between the generator and the main transformer, and the high voltage working transformer T3 and T5 are connected at the low voltage side of the generator. Between the generator and the main transformer and the transformer used in the plant are closed busbars with separate phases. In order to limit short circuit current, low voltage split winding transformer is used in high voltage factory working



transformer. The high voltage plant starting/standby transformer T4 has both the standby transformer function as a plant starting transformer, supplying power from the 330kV busbar. Due to the need to obtain power supplying from the system, a low-voltage split winding transformer with on-load voltage regulation function is used.

6kV high-voltage bus for the plant, each boiler is divided into two sections, starting/standby transformer low-voltage winding are respectively connected to the standby A, B two sections, in these two sections are also connected with the public load, also known as the common section. The 6kV high-voltage busbar is connected with 6 low-voltage transformers for the factory. In the 380/220V factory low-voltage circuit, each unit is divided into two parts. The diesel generator set with quick start of AC accident safety power supply is connected to the bus bar in section IV to ensure that the host can stop safely when the factory power supply is interrupted. The wiring diagram of the plant power supply is shown in Figure 2.

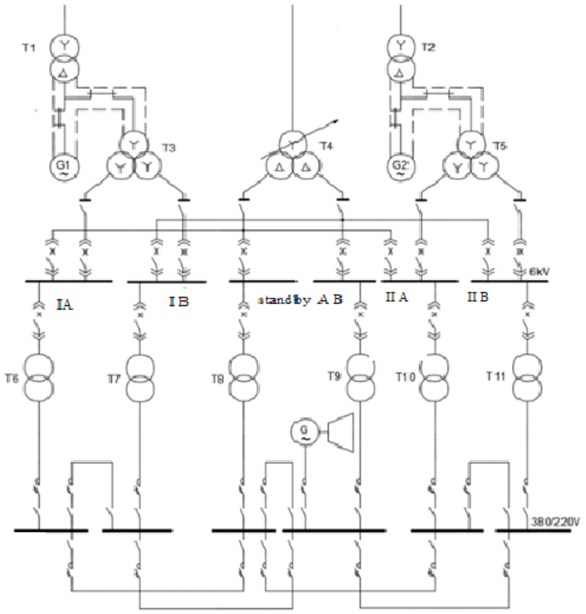


Fig. 2. Plant Electrical Wiring Diagram

4 Short-Circuit Current Calculation

In the process of the design of the main wiring of the power plant, the short-circuit current calculation occupies a pivotal position. This calculation not only provides a key reference for the selection of electrical equipment, but also involves the precise calculation of dynamic stability correction and thermal stability correction. Therefore, in order to ensure the stable operation of the power plant and prevent the potential risk of short circuit, it is particularly important to calculate the short circuit current accurately. This is not only a technical requirement, but also a safety guarantee work, which is an indispensable part of the power plant design process. According to the main wiring diagram of the power plant, take S_b=1000 MV·A, U_b=U_{av}, and the equivalent circuit diagram is drawn as shown in Figure 3.

Fig. 3. Preliminary Equivalent Circuit Diagram

The short-circuit current calculation results on the 330kV side of the main transformer are shown in Table 1.

Table 1. Calculation Result of Short Circuit Current on 330kV Side of Main Transformer

Short-circuit parameter							
Power	I /kA	$I_{0.1s}$/ kA	$I_{0.2s}$/ kA	I_{1s}/ kA	I_{2s}/ kA	I_{4s}/ kA	i_{im}/ kA
System	5.58	5058	5.58	5.58	5.58	5.58	14.2
Factory	4.25	3.64	3.3	2.81	2.79	2.78	11.2
Total	9.83	9.22	8.88	8.39	8.37	8.36	25.32

5 Selection of Electrical Equipment

5.1 Selection and Verification of Breakers

The maximum continuous working current of 330kV circuit is:

$$I_{max}=\frac{1.05P_N}{\sqrt{3}U_N\cos\varphi}=\frac{1.05\times 300\times 10^3}{\sqrt{3}\times 330\times 0.85}=648.36A \quad (2)$$

Take the short-circuit calculation point as k1 point in Figure 4.1, and the short-circuit current through the generator circuit is the difference between the total short-circuit current of the system minus the short-circuit current of the generator in this circuit, that is

$$I''=9.83-\frac{1}{2}\times 4.25=7.705kA \quad (3)$$

In a similar way, $I_{p0.1s}$=7.4kA; $I_{p0.2s}$=7.23kA; I_{p1s}=6.985kA; I_{p2s}=6.975kA; I_{p4s}=6.97kA; i_{im}=19.76kA

According to the design requirements, the selection conditions of the circuit breaker are shown in Table 2.

Table 2. Selection Conditions of Circuit Breaker

Rated current	IN 1 Imax=648.36 A
Rated voltage	UN 1 330kV
Rated breaking current	INbr 1 I =7.705kA
Rated short-circuit closing current	iNc1 1 iim =19.76kA

Therefore, SRM330-30/2500 circuit breaker is selected initially, and then the thermal stability check and dynamic stability check are carried out on this type of circuit breaker. The thermal effect of short circuit current is:

$$Q_k=\frac{\left(I''^2+10I_{\frac{tk}{2}}^2+10I_{tk}^2\right)}{12}=49.54(kA)^2\cdot s \quad (4)$$

$$I_t^2t=40^2\times 3=4800(kA)^2\cdot s\geq 49.54(kA)^2\cdot s \quad (5)$$

$$i_{es}=100kA\geq i_{im}=19.76kA \quad (6)$$

Meet the thermal stability requirements. Meet the requirements of dynamic stability.

5.2 Selection and Verification of Isolation Switch

The isolation switch and circuit breaker are selected in the same way, and the selection results are shown in Table 3.

Table 3. Model and Parameters of the Selected Isolation Switch

Model number	GW10-330D/1600
Rated voltage	330kV
Rated current	1600A
Peak value of dynamic stable current	100kA
3s heat stable current	40kA

6 Design of Power Distribution Device

When choosing the type of power distribution device, it should be based on the actual situation, first according to the local environment, climate and other conditions for the initial selection, and then good economy of power distribution device are chosen through the specific needs of the choice of high reliability. The geography of this design is favorable, with no earthquakes and very few thunderstorm days, as well as no significant environmental pollution.. In addition,the 330KV distribution of this design is of high voltage and should be used as a medium-sized distribution unit, so in summary, the design selects an outside-the-house type medium-sized distribution unit. Among them, the safe distance between the main transformer and the building is greater than 1.25 meters, and the fire protection net distance between the two transformers is greater than 5 meters. The valve-type arrester is installed on a 0.4m high foundation. To ensure safety, a fence around the arrester is put. The safety inspection inside the outdoor distribution device is crucial, so the inspection path with a width of 0.8 to 1 meter is specially planned, and the cable trench cover can be double used as part of the inspection path.

7 Conclusion

The core of this design is the preliminary design of the electrical part of the thermoelectric unit of a power plant. During the design process, the national design specifications are strictly followed to ensure that each design complies with national and industry standards. At the same time, reliability is the first principle always adhered to in the design process. Under the premise of ensuring that the functional and performance requirements of the design scheme are fully met, the operation and maintenance costs of the whole system are reduced by optimizing the structure and selecting efficient equipment, and the overall reliability is improved. Through the short-circuit current calculation, the selected bus and electrical equipment meet the requirements and are economically and technically reasonable, so that the design of the power plant in line with the country's development direction and meets the needs of the people

The funding support for this project came from the 2023 Quality Engineering Project of Guangdong University of Science and Technology（GKZLGC2023156）.

References

1. Shi Yanbo, Lin Shenghui. Specification Design of Electrical Part of Power Plant [J]. Mechanical and Electrical Information, 2023(08):20-25.
2. Yang Hongxia. Design of Main Electrical Wiring for Primary System of Substation [J]. Applications of Integrated Circuits, 2022, 39(05): 100-103.
3. Zhang Yang, Wang Zijing, Hu Yue, etc. Design of Electrical Part of 2×100MW+2×600MW Thermal Power Plant [C]. Jilin Motor Engineering Society. Awards Proceedings of 2022 Academic Annual Meeting of Jilin Electrical Engineering Society. Jilin University Press, 202:15.
4. Gao Chengkai. Discussion on Technical Measures of Energy Saving and Consumption Reduction in Thermal Power Plants [J]. Cleaning the World, 2021, 37(10):128-129.
5. Fang Lei. Research on Several Methods of Electric Energy Saving and Consumption Reduction in Thermal Power Plants [J]. Science and Technology Innovation, 2023(17):147-149.
6. Luo Lijia. Calculation and Analysis of Busbar Protection Setting for High Voltage Plant of 300 MW Thermal Power Unit [J]. Jilin Electric Power, 2022, 50(04):45-48.
7. Northwest Electric Power Design Institute, Ministry of Water Resources and Electric Power. Electrical Engineering Power Design Manual: Electrical Primary Part [M]. Beijing: China Electric Power Press,1989.