RESEARCH ON MULTI-LEVEL LOOP CONNECTION SYSTEM OF AUXILIARY POWER SYSTEM IN LARGE POWER PLANTS

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Abstract

The auxiliary power system of traditional large power plants is characterized by large power supply load, wide power supply range, scattered load points and large capacity of individual motors. It mostly adopts two-level voltage supply and single busbar segmented connection. in operation, there exists a situation where when the main power supply source of this section of the busbar is lost, such as when the adjacent busbar is under maintenance or has a fault, it may block the power supply from the external backup power to other normal busbar sections. The power supply reliability, continuity and operational flexibility of the factory power system are relatively limited. In severe cases, it will increase the probability of accidents. This paper proposes a multi-level loop-connected power supply wiring system for Large Power Plantss. By forming electrical loop-connected wiring through electrical connections at the main power supply distribution center and the remote regional distribution center, the reliability, continuity and operational flexibility of the power plant system are improved, and the accident rate during operation is reduced.

1. Introduction

Large power plant auxiliary power system has a large power supply load, wide range of power supply, load points scattered, big single motor capacity, auxiliary power system power supply usually includes the main power supply, external standby power and emergency security power. Among them, the main power supply is connected to the generator outlet, external standby power supply leads from the nearby regional power grid or external construction power supply is retained and used as a standby power supply, the emergency security power supply mostly adopts diesel generator sets, and sometimes the power plant also sends power from the electric power system backward to the power plant as the plant's auxiliary power supply. The power supply distance of Large Power Plantss usually exceeds the power supply radius of 0.4kV primary voltage, and two voltage levels are mostly used for power supply (e.g., 10kV auxiliary power voltage and 0.4kV auxiliary power voltage), which are led from the generator outlet to the medium-voltage main distribution center, and then stepped down and led to the nearby low-voltage power distribution center. In the power supply area far away from the main distribution center, a remote regional distribution center is set up, and the remote regional distribution center is also powered by two voltage levels, with the main supply leading to the main distribution center and after voltage reduction, it is led to the nearby low-voltage distribution center in the area [1].

Medium-voltage auxiliary power system of the main power distribution center and remote regional distribution center of large power plant usually adopts the single-bus segmented wiring system, each main power supply is connected to a section of the single-bus segmented bus, and the external standby power supply is selected to be connected to a certain section of the bus, and the emergency power supply can be connected to either the main power distribution center or the remote regional distribution center according to the need, and both can be used as the emergency power supply of the whole plant for emergency security, The voltage level can be selected according to the scale of the power plant and connected to the medium-voltage auxiliary power system bus or to the key load section bus of the low-voltage power distribution center of the power plant. The low-voltage auxiliary power system wiring of the power plant adopts single-bus or single-bus sectionalized wiring as required [3].

The current common auxiliary power system wiring of large power plants, although it has been applied in many projects, there are some problems. When the main supply power of a section of the bus is lost, it is necessary to use the neighboring bus as the main supply power for this section of the bus power supply, when the neighboring bus is overhauled or malfunctioned, and this section of the bus does not have access to external standby power, there will be a loss of power in this section of the bus. Similarly, for buses connected to external standby power supply, when the bus of this section loses the main supply power and the neighboring buses are overhauled or faulty, the power supply from the external standby power supply to other normal bus sections may be blocked. A similar situation may occur when the emergency security power supply is put into operation, and the reliability, continuity and operational flexibility of the power supply of the auxiliary power system are relatively limited, which may increase the chance of accidents in serious cases.

In this paper, a multi-level loop connection system of auxiliary power system is proposed to solve the problems of low power supply reliability, continuity and operational flexibility, and high probability of accidents in the existing auxiliary power system of large power plants. The wiring sets up the main power distribution center and the remote regional power distribution center, and sets up multiple main power supplies in the main power distribution center to provide power from the main power distribution center to the remote regional power distribution center. meanwhile, the main power distribution center and the remote regional distribution center respectively introduce external backup power. In order to ensure the reliability of power supply to the remote important electrical loads, emergency power supply is also set up in the remote regional distribution center, which constitutes an electrical loop connection wiring through the electrical connection between the main power distribution center and the remote regional distribution center. This auxiliary power supply wiring can effectively improve the reliability, continuity and operational flexibility of the current large power plant auxiliary power system, reducing the incidence of accidents in operation [1][4][5]. The multi-level loop connection system of auxiliary power system for large power auxiliary power system proposed in this paper has been authorized as a utility model patent.

2. Typical Single Line of Multi-level Loop Connection System for Large Power Plant Auxiliary Power System

Fig. 1 shows a typical single line of this wiring, the main power distribution center is set up with four segments of medium voltage buses, and the segments of the main power distribution center are wired with single busbar segments, and each segment of the medium voltage buses is connected to a main power supply respectively. Connect section I MV busbar of the main power distribution center with section IV MV busbar, so as to form a loop connection between sections of busbars of the main power distribution center. Three sections of medium-voltage busbars are provided in the remote regional power distribution center, and each section of the busbars in the remote regional power distribution center also adopts single-bus segmented wiring, so as to provide a power supply from section I medium-voltage busbars in the main power distribution center to section V medium-voltage busbars in the remote regional power distribution center, and to provide a power supply from section IV medium-voltage busbars in the main power distribution center to section VI medium-voltage busbars in the remote regional power distribution center, This forms a loop connection between the seven bus sections of the main power distribution center and the remote regional distribution center. The main power supply of the remote regional distribution center is two power supplies from the main power distribution center.

One external standby power supply is introduced into the section I medium-voltage bus of the main power distribution center and the section VII medium-voltage bus of the remote regional power distribution center as a standby power supply after the loss of all main power supplies. In addition, in order to ensure that the Large Power Plants has the black-start capability in case of loss of external power supply as well, a diesel generator set is also connected to the section VII MV bus of the remote regional distribution center as the emergency security power supply and black-start power supply of the whole plant.

The above typical single line of multi-level loop connection system and its control method, by planning the power supply area and setting up the main power distribution center and the remote regional power distribution center, makes the power supply either operation relatively independently, realizing the power supply in the vicinity, and facilitating the maintenance and management in the local area, or operation jointly to ensure the continuous power supply. All section of MV work bus of the main power distribution center forms a loop connection, and the main power distribution center builds a large loop connection with the MV bus of the remote regional distribution center by providing two main power supplies to the remote regional distribution center, thus ensuring that when any section of the MV work bus is maintained or malfunctions, the other sections of the MV work buses can operate normally, and thus improving power supply reliability, continuity and flexibility of operation.

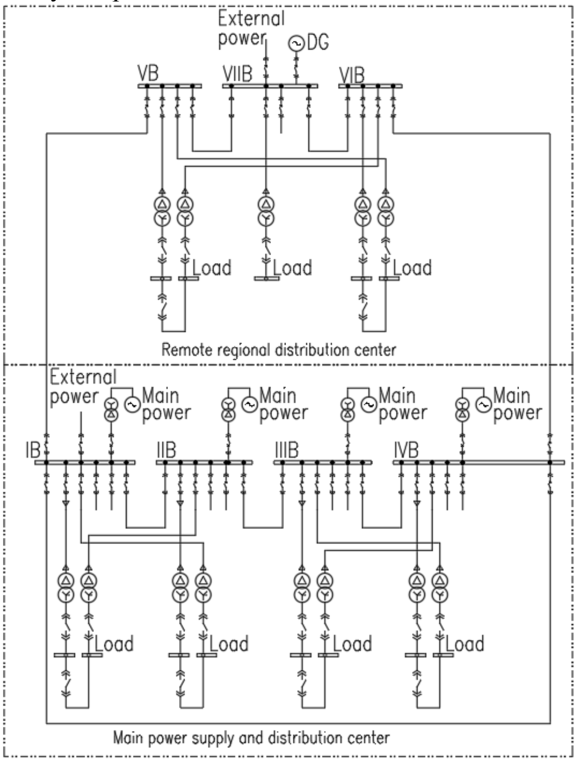

Fig. 1 Schematic diagram of the principle of Multi-level Loop Connection System for Large Power plant auxiliary power System

3. Analysis of Problems Related to Multi-level Loop Connection System for Large Power plant auxiliary power System

3.1 Power supply method of auxiliary power supply

From Fig. 1, it can be seen that when both the loop circuit breaker and the sectional circuit breaker of the main power distribution center are closed, the phenomenon of circulating current occurs between the busbars of each section in the main power distribution center. Similarly, when the loop circuit breaker and sectional circuit breaker of the remote regional distribution center and the main power distribution center are closed, loop current phenomenon will also occur between the seven bus sections between the main power distribution center and the remote regional distribution center. This requires that in operation, a reasonable circuit breaker opening and closing method should be used, i.e., to ensure the reliability of the power supply of other sections of MV working bus when any section of MV working bus is maintained or faulty, and to avoid the occurrence of loop current phenomenon, and meanwhile to avoid the connection of multiple power sources supply to the same section of bus.

According to the above power supply requirements, the power supply sequence of the main power distribution center and the remote regional power distribution center for each section of the bus is as follows.

The power supply sequence of the main power distribution center is as follows: the first power supply is the power supply from the generator outlet auxiliary transformer connected to the busbars of each section; the second power supply is the power supply from the busbars of adjacent sections when the generator power on the busbars of the section withdraws; the third power supply is the power supply from the medium-voltage busbars in section I of the main power distribution center looped with medium-voltage busbars in section IV; the fourth power supply is the power supply from the external source; the fifth power supply is the reverse power supply from the remote regional power distribution center. In operation, when the first power supply is used, all bus contacting circuit breakers should be disconnected to avoid multiple power supplies being connected to the same section of bus. When the second power supply is used, only the circuit breakers between adjacent sections of the supply bus are closed, and all other bus contacting circuit breakers are disconnected. When the third power supply is used, section I medium-voltage bus and section IV medium-voltage bus can be used as the power supply for each other after the power supply of it section bus is withdrawn. When the fourth power supply is used, the contacting circuit breakers of each bus section are closed, but the loop circuit breakers of section I medium-voltage bus and section IV medium-voltage bus shall be disconnected. When the fifth power supply is used, the circuit breaker opening and closing status is similar to that of the fourth power supply, but since the fifth power supply is only used as an emergency power supply, care should be taken to supply power only to the emergency loads on the buses of each section.

The power supply sequence of the remote regional distribution center is as follows: the first power supply is the power supplied from the section I medium-voltage busbar and section IV medium-voltage busbar of the main power distribution center, and only one power supply should be connected meanwhile during normal operation. The second power source is the external backup power source connected to section VII MV bus when both power sources introduced from the main power distribution center are withdrawn. The third power source is a diesel generator set connected to the medium voltage bus of section VII, which is only used as an accident security power source and a black start power source for the power station.

3.2 Phase difference during auxiliary power switching

In operation, For Large Power Plants auxiliary power system multi-level loop connection system, the switching between the main supply power supply and the external power supply is relatively complex, mainly including the following ways: a) Normal switching: commonly used in the process of generator startup and shutdown; b) abnormal switching: used for the plant bus non-normal voltage drop or loss of voltage, as well as man-made misuse led to the removal of the normal power supply; c) accidental switching: used for the occurrence of faults other than bus faults led to the disconnection of the normal power supply; Among them, normal switching is usually a simultaneous operation, and the phase angle difference between the power sources is close to zero. Non-normal switching and accidental switching, due to the main supply power and external power from different power sources or power systems, and the different of circuit breakers closing and tripping times and other factors, in the power switching, the external power supply and the normal power supply between the phase difference will sometimes be larger. The large phase difference will generate loop current, which may lead to protection misoperation and also cause some damage to the transformer[7-10]. Therefore, during abnormal power switching and accidental power switching, measures should be taken to reduce the phase difference between the normal power supply and the standby power supply during switching.

Currently common ways to limit the phase difference between the normal power supply and the standby power supply during power switching include: a) using fast switching devices to ensure that the load can be quickly switched from the faulty power supply to the standby power supply in the event of a power failure. b) implementing stringent power switching regulations for auxiliary power supply, taking into account the high reliability of the main power supply in large power plants, and the low probability of simultaneous failures of multiple main power supplies, phase angle differences between power supplies usually occur when switching between the main power supply and external power supplies. which can be achieved by setting a reasonable operation sequence, such as “jumping first and then closing”, i.e., the standby power supply is jumped off and then closed on the normal power supply. In this case, there will be a short-term loss of power at the plant busbar, and a safe transition can be realized by adjusting the plant load rate at the time of switching.

3.3 Emergency busbar in Multi-level loop connection system for large power plant auxiliary power system

In large power plants, taking into account the different importance of electromechanical equipment loads, for the electromechanical equipment loads involved in the operational safety of the plant, can be used to set up an emergency bus, to ensure the reliability of power supply to the key loads, and standby power supply (such as external power supply), the whole accident security power supply (such as diesel generator sets), access to the section of the bus. Emergency bus in a multi-level loop connection system of auxiliary power system in large power plants, can be set the multi-level loop connection system, In the event of loss of power from the main power supply of the whole plant, power is supplied to the loads of the main power distribution centers and remote regional distribution centers to ensure the demand for power supply of the whole plant, and also to ensure the reliability of power supply to the key loads of the plant in the event of overall failure of a certain distribution center to satisfy the requirements of accidental security of the whole plant. In recent years, in the auxiliary power system of many projects at china and abroad, it has become common to set up emergency busbar in the design scheme of auxiliary power system, and from the operation situation, this method can well guarantee the reliability and flexibility of the power plant.

3.4 Earthing of Multi-level loop connection system for large power plant auxiliary power system

Large power plant multi-level loop connection system for medium voltage auxiliary power system, the current domestic large power plant medium voltage auxiliary power system is generally used neutral ungrounded mode, when a single-phase grounding fault occurs, the auxiliary power system can generally continue to run for 2h, although it can ensure that the auxiliary power system is reliable power supply, but the grounding method is difficult to achieve sensitive and selective grounding protection, which may lead to the expansion of the single-phase grounding fault For the accident. Therefore, in the specific application, should analyze the method of large power plant multi-level loop connection system grounding.

Large power plant load distribution is wide, the main power distribution center and the remote area distribution center is far away, the electrical part of the distribution center is connected by cable, due to the long cable path, the cable's capacitance to ground is large. The ground capacitance of the cables is the main component of the capacitive current that constitutes the power system of the plant.

The formula for calculating the capacitive current of the auxiliary power system is shown in Equation (1):

$$I_C = \sqrt{3} U_e \omega C \tag{1}$$

where I_C is the single-phase grounding capacitance current, U_e is the rated line voltage of the auxiliary power system, ω is the angular frequency, f is the rated frequency, and C is the capacitance of each phase of the auxiliary power system to ground (μF).

According to the research results[11], when the single-phase ground fault capacitance current is not greater than 7A, the ungrounded method can be used, and the protection action in signaling. When the single-phase ground fault capacitance current is greater than 7A, it is appropriate to use the neutral point of low-resistance grounding method, the protection action in the trip. Auxiliary power system neutral point by low resistance grounding, it can change the time constant of the circuit, increase the circuit loss, accelerate the attenuation of the oscillation process, and can effectively suppressing the arc grounding overvoltage. Compared with the neutral point ungrounded system, auxiliary power system neutral point with low resistance grounding, due to the resistance of the damping and loss effect, the arc over the zero quenching, zero sequence residual voltage through the resistor discharge, to avoid the arc rekindle - quenching - rekindle the oscillation process, thus limiting the over-voltage rise, over-voltage is limited to - a lower level. meanwhile, to provide a path for the zero-sequence current, the smaller the resistance value of the grounding resistance, the larger the fault current, which allows the zero-sequence current protection relay to act quickly and sensitively to remove the fault line in time, and avoid further expansion of the accident[12].

When choosing the grounding resistance, it should be ensured that when single-phase grounding fault occured, the resistance current is not less than the capacitance current, and the total single-phase grounding fault current should enable the protection device to accurately and sensitively trip. The calculation formula for the grounding resistance value is shown as Formula (2) :

$$R_N = \frac{U_e}{\sqrt{3} I_R} \tag{2}$$

Among them, R_N represents the resistance value, and I_R is the grounding resistive current.

3.5 Relay protection configuration and setting of Multi-level loop connection system for large power plant auxiliary power system

The relay protection of large power plants implements the near-backup principle and adopts a dual configuration. Each set of protection contains complete main and backup protection functions. When any device or circuit breaker fails to operate, another set of protection at the same level realizes backup. The TA and TV of the two sets of protection are respectively taken from independent windings, and the protection ranges overlap and cross, thus achieving physical independence. The protection scope should cover all key equipment of the plant power system, including: a) High-voltage auxiliary transformers and MV busbars; b) External power supply c) Busbar contact circuit breaker; d) Feeder circuit breaker e) Low-voltage auxiliary transformers; f) Electric motor. The windings should be reasonably distributed to avoid protective dead zones.

According to the above principles, the protection equipment for high-voltage auxiliary transformers and MV busbars in the main power distribution center and the remote regional distribution center all adopt a dual configuration. The main protection of high-voltage auxiliary transformers and busbars can adopt longitudinal differential protection or current short-circuit protection. Through instantaneous action, the circuit breakers on each side of the high-voltage auxiliary transformers are disconnected to achieve the elimination of interphase short-circuit faults in the windings of the high-voltage auxiliary transformers and the MV busbar. The backup protection for high-voltage auxiliary transformers and busbars can adopt overcurrent protection. This relay protection sets two time limits for interphase short circuits in the low-voltage winding of the transformer and the load busbar. The first time limit acts on the disconnection of the low-voltage side circuit breaker of the high-voltage auxiliary transformers, and the second time limit acts on the high-voltage circuit breaker of the high-voltage switchyard, the disconnection of the generator circuit breaker, and the disconnection of the low-voltage side switch of the high-voltage auxiliary transformers[15]. In addition, to measure the single-phase current on the high-voltage side of the high-voltage transformer, overload protection can also be set up.

The main protection of the external power supply adopts time-limited current instantaneous breaking protection, and the backup protection adopts overcurrent protection. Both the main protection and the backup protection operate on the incoming line circuit breaker that breaks the external power.
The main protection of the LV auxiliary transformer adopts time-limited current interruption protection, and the backup protection adopts overcurrent protection, and both the main protection and backup protection are operated at the circuit breaker on the high voltage side of the LV auxiliary transformer. In addition, it can be considered to configure zero sequence overcurrent protection for the LV auxiliary transformer as the LV auxiliary transformer LV side ground fault protection.

The main protection of each busbar contact circuit breaker and feeder circuit breaker adopts time-limited current instantaneous breaking protection, and the backup protection adopts overcurrent protection. Both the main protection and the backup protection operate on the busbar contact circuit breaker and the feeder circuit breaker.

The main protection of each motor adopts current instantaneous protection, while the backup protection adopts unbalanced protection and low-voltage protection. Both the main protection and the backup protection operate on the feeder circuit breaker led to the motor.

The typical diagram of the protection configuration at all levels is shown in Fig.2

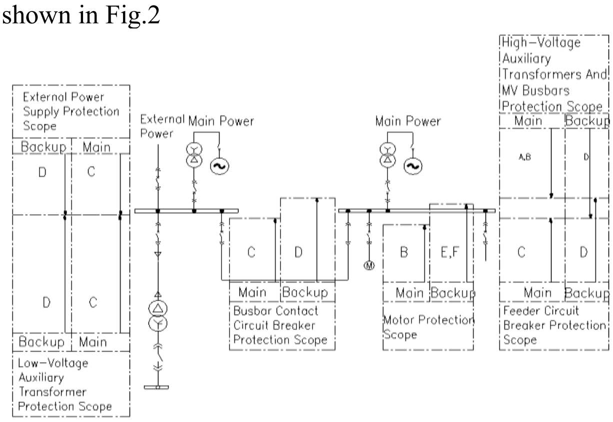

Fig. 2 The typical diagram of the protection configuration at all levels

Among Fig. 2, A represents Longitudinal differential protection, B represents Current short-circuit protection, C represents Time-limited current instantaneous breaking protection, D represents Overcurrent protection, E represents Unbalanced protection, F represents low-voltage protection.

3.6 Example 1: Jinsha river Xiluodu hydropower station

Xiluodu Hydropower Station is a giant hydropower station on the lower reaches of the Jinsha River and the third largest hydropower station in China, with nine hydroelectric generating units of 770MW capacity installed in the underground plants on the left and right banks. The auxiliary power system of Xiluodu Hydropower Station is characterized by wide power supply range, large power supply load, load distribution scatter, long power supply distance and large capacity of single motor. In order to improve the power supply reliability, operation flexibility and equipment investment economy of the plant power system, the power station adopts independent plant power systems on the left and right banks.

Take the underground plant on the left bank as an example, the main power distribution center of the underground plant is of 10kV voltage level, adopting single busbar segmented wiring, with a total of six busbars, which are respectively connected to the main power supply from the units of #2, #3, #5, #6, #8, #9, and a loop connection is formed between the busbars of the I section and the busbars of the VI section. Power is drawn from section I busbar and section IV busbar of the main power distribution center respectively, and connected to section VII busbar and section IX busbar of the left bank external power distribution center respectively, forming a loop connection with the left bank external power distribution center. The power supply from section II busbar and section V busbar of the main power distribution center is connected to the main power distribution center of the underground plant on the right bank, which also constitutes a loop connection with the main power distribution center of the underground plant on the right bank. The left bank external power distribution center is set up with three sections of bus, and the external power supply and diesel generator sets are connected to the VIII section of bus. The external power supply is connected to section III bus of the main power distribution center of the underground plant meanwhile. The main power distribution center of the underground plant on the right bank provides one round of power supply to the section IX bus of the power distribution center on the left bank, which is used as the backup power supply of the power distribution center on the left bank.

The schematic diagram of the multi-level loop connection of the left bank plant power system of Xiluodu Hydropower Station is shown in Fig. 3.

Literature [5] has analyzed the auxiliary power system reliability of Xiluodu hydropower station auxiliary power system in the early generation period, permanent operation period and right bank island operation conditions in depth.

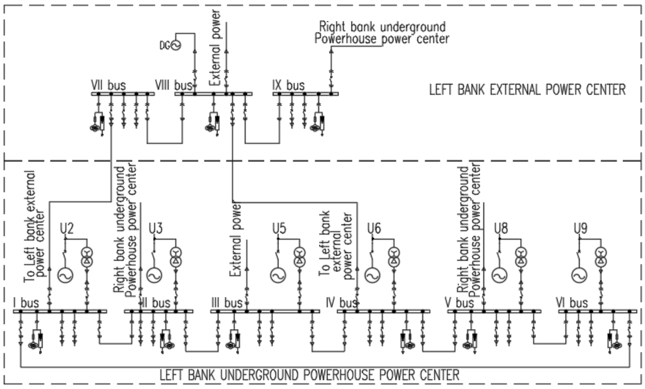

Fig. 3 The left bank plant power system of Xiluodu Hydropower Station

In this paper, in order to verify the reliability of multi-level loop connection system of large power plant, only the reliability of auxiliary power in permanent period is analyzed. It can be seen that, in the normal operation period of permanent, the main power supply of 10kV bus in the plant is taken from the corresponding unit plant high transformer connected between the generator outlet circuit breaker and the low voltage side of the main transformer. When the unit is running, the auxiliary power is fed from the unit side, and when the unit is shut down, the auxiliary power is fed backward from the HV side of the main transformer. Only when GIS is de-energized and the unit is fully stopped, the main supply of power from the plant buses is de-energized. meanwhile, the six sections of buses in the plant form a loop connection, and the buses are operated in sections. Adjacent busbars can be used as standby for each other. A set of 10 kV self-provisioning devices is installed in each section of the busbar, which realizes the rapid automatic reversal of power supply of adjacent busbars through self-provisioning and further improves the reliability of the power system of the plant. The main power supply of the bus of the external system is taken from the internal bus, therefore, the stability level of the internal bus determines the reliability of the external bus. meanwhile, when the plant bus loses power, it can also be supplied to the plant bus by the power supply from outside the plant through the contact line. Realize the two-way power supply inside and outside the plant, which further improves the reliability of the auxiliary power system. Due to the left and right bank of the plant set up between the two 10kV contact line. Setting up a contact line between the plant, when the bank of the auxiliary power system is all out of power. The power supply on the other side of the river can be used as the first backup to gradually restore the auxiliary power system. If the power supply on the other side of the river is not available, it can be connected from 110 kV Xiluodu center substation to the outside and inside the plant buses of the two construction power supply as the second backup power. If the construction power supply also loses power meanwhile. A diesel generator set is manually put into operation as a security power source to supply power to the plant loads by means of reverse power feed.

It can be concluded that, during the permanent operation period, the auxiliary power system of Xiluodu power station has been reasonably designed in terms of the configuration of the main supply and the backup power source, the auxiliary power system single line scheme and other aspects. It ensures the reliable power supply to all power-using equipments in the power station.

3.7 Example 2: Jinsha River Xiangjiaba hydropower station

Xiangjiaba Hydropower Station is a giant hydropower station on the lower reaches of the Jinsha River, with four hydroelectric turbine generator sets of 800MW capacity installed in the underground plants on the left and right banks. The characteristics of the plant power system of Xiangjiaba Hydropower Station are similar to those of Xiluodu Hydropower Station, which also adopts independent plant power systems on the left and right banks.

Still take the underground plant on the left bank as an example, the main power distribution center of the underground plant is of 10kV voltage level, adopting single busbar segmented wiring, with a total of four busbars, which are connected to the main power supply from the four units on the left bank respectively, and the I busbar constitutes a loop connection between the I busbar and the IV busbar. The I bus and III bus of the main power distribution center are respectively connected to the I bus of the two external power distribution centers, and the main power distribution center of the underground plant on the right bank also provides a power supply to the II bus of the two external power distribution centers, so the two external power distribution centers and the main power distribution centers of the underground plants on the left and the right bank form a loop connection. A power supply is drawn from the section II bus of the main power distribution centers on the left and right banks to the section II bus of the main power distribution center of the underground plant on the opposite bank. The external power supply is also connected to the II bus of the main power distribution center of the underground plant. The diesel generator sets are connected to the external power distribution centers of the left bank.

The schematic diagram of the multi-level loop connection of the plant power system on the left bank of Xiangjiaba Hydropower Station is shown in Fig. 4:

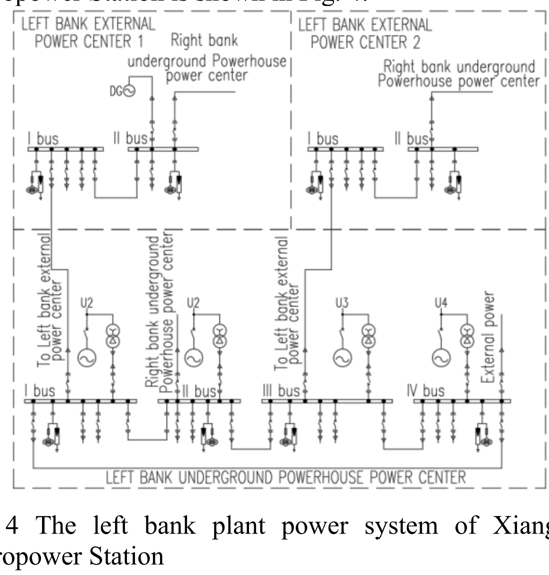

Fig. 4 The left bank plant power system of Xiangjiaba Hydropower Station

As can be seen, Xiangjiaba Hydropower Station plant power system adopts 10kV and 0.4kV two-level voltage power supply, auxiliary power is connected from the low voltage side of the main transformer of each unit, external standby power supply from the retained construction substation and the opposite bank of the 10kV plant power source, the left and right bank of the plant power source as a standby for each other, and another diesel generator set as a dam security power supply. The selection of power supply meets the needs of plant power load under various operation modes and ensures the reliability and continuity of power supply.

4. Conclusion

(1) This paper discusses the large power plant auxiliary system multi-level loop connection system, through the main power distribution centers and remote regional power distribution centers in the electrical connection constitutes an electrical loop connection, to avoid when a section of the distribution center bus loses the main power supply, the adjacent bus maintenance or failure, may block the external standby power supply to the other section of the normal bus power supply phenomenon. Effectively improve the reliability, continuity and operational flexibility of the current large power plant auxiliary power system, reducing the incidence of accidents in operation.

(2) Auxiliary power system using multi-level loop connection system, should develop a reliable circuit breaker operating procedures, to avoid the auxiliary power supply switching, in the bus between the segments of the phenomenon of circulating current or multiple power sources supply to the same section of bus.

(3) When the plant power system has more than one power supply, and the power supply from different power systems, attention should be paid to avoid the power switching, the power supply between the phenomenon of large phase difference. If necessary, it can take the “first jump after closing”, that is, the standby power supply after jumping open and then close the working power supply. However, when using this method, attention should be paid to measures to reduce the short-term loss of power time.

(4) in the large power plant auxiliary power system design, should review the auxiliary power system capacitance current, single-phase grounding fault capacitance current is not greater than 7A, can be used without grounding, the protection action in the signal. When the single-phase ground fault capacitance current is greater than 7A, it is appropriate to use the neutral point of low-resistance grounding method, the protection action in the trip.

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