

# Research and Application of Tunnel Power Supply System

Song Zhao

Department of Mechanical and Electrical Engineering Xijing University

Xian 710123, China,

610633400@qq.com

**Abstract.**—Highway tunnel projects are generally built in areas with complex topography, such as mountainous and hilly areas, while the power supply in mountainous areas is relatively weak. There are some difficulties in power supply for some relatively large tunnel projects. In this paper, a practical power supply scheme of expressway is introduced to ensure that it meets the requirements of power supply, to ensure that the power supply is stable, safe and convenient to maintain.

**Keywords**— Highway, Tunnel, Power supply system, Transformer substation

## I. TUNNEL ENGINEERING INTRODUCTION

The Qinling Zhongnanshan Tunnel crosses the Zhongnanshan Mountains in the Qinling Mountains. The tunnel is 18.020 kilometers long. It has two tunnels and two lanes on the upper and lower lines. The import is located on the right bank of Shibianyu River, Qingcha Village, Shibianyu Township, Chang'an District, Xi'an City, with an elevation of 896 m; the export is located on the right bank of Taiyu River, Xiaoyujie, Yingpan Township, Zhashui County, with an elevation of 1026 M. There is a herringbone longitudinal slope in the cave. The maximum longitudinal slope is 1.1% and the maximum buried depth is 1640m.

## II. LOAD DISTRIBUTION

The main electric loads in the tunnel are emergency lighting, general lighting, jet fan, axial fan, communication monitoring equipment, etc. Among them, the first load is general lighting, emergency lighting, communication monitoring equipment, rotating fans, jet fans for smoke exhaust; the other jet fans are secondary loads. The main electric loads outside the tunnel are fire fighting facilities, equipment control, checkpoints and supporting facilities.

## III. POWER SUPPLY

A 110/35/10 kV substation is set up at the south entrance of the main tunnel to supply power to the main tunnel and the lead tunnel. In order to ensure power supply for important loads such as monitoring in service area, a power generation and distribution station is set up in service area, which is connected with two 10 kV external power supply and equipped with diesel generator set. Other buildings are supplied by box-type substations in different areas.

## IV. POWER SUPPLY SYSTEM

Structural Chart of Power Supply and Distribution System of Zhongnanshan Highway Tunnel

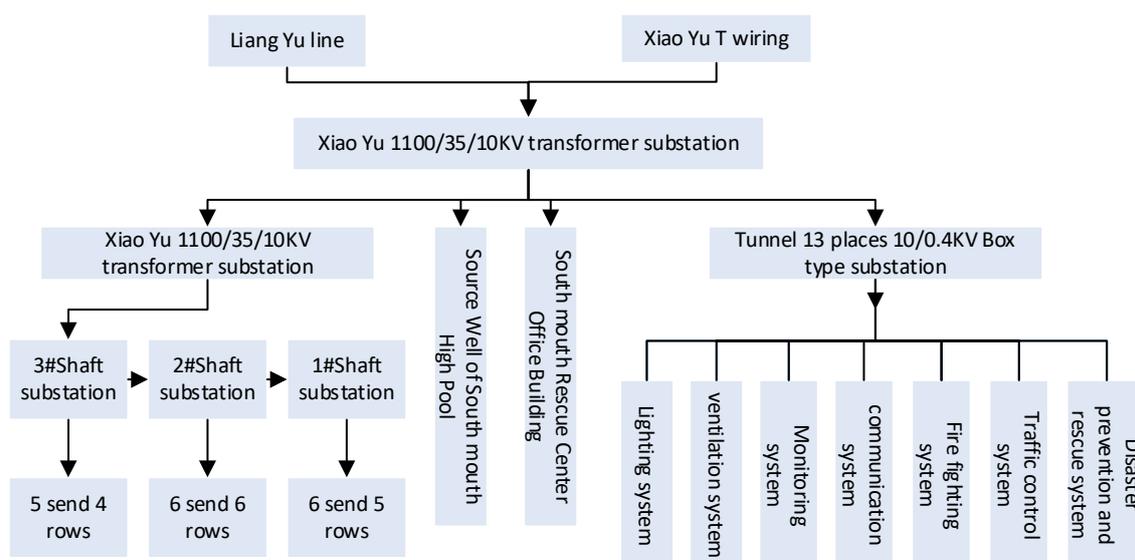


Figure 1. Power Supply and Distribution System of Qinling Zhongnanshan Highway Tunnel

As shown in Fig. 1, all kinds of loads in the tunnel are supplied by 10/0.4 kV box substation and 35/6 kV substation of shaft fan room in the tunnel. 10/0.4 kV box-type substation is located in the branch tunnel of the vehicle crossing passage with a spacing of about 1.5 km. Each box-type substation is equipped with two transformers. The high voltage side is connected by a single bus, and the low voltage is connected by a single bus segment. Normally, two transformers operate simultaneously; when one transformer is overhauled or faulted, the other transformer supplies power to all loads. The two 10 kV power supply lines of each box substation are connected by four 10 kV trunk lines from 110/35/10 kV substation in South mouth in turn in tunnels of East and West lines. The power supply of the 35/6kV substation ring network in the tunnel is supplied by two feedbacks of 35kV trunk lines from South mouth 110/35/10kV substation, and the two feedbacks are laid in the East-West tunnel respectively.

#### *A. 110KV Xiaoyu Substation has two Routes.*

Liangyu Line (21.259km) is the main power supply and Xiaoyu T-connection (5.899km) is the standby power supply. Through the high-voltage combined electrical appliances on the 2nd floor of the Substation (including two sets of equipment of the input-output line interval and the main transformer interval), the input-output line interval controls the entry of Liangyu line into the substation; the main transformer interval is responsible for feeding transformers. Power supply, including control circuit breaker, voltage, current transformer and so on. Because of the phase sequence problem of transformer, the bus bar fast disconnecter has not been put into use and can not automatically switch between two transformers. Then it enters two transformers, one main transformer and one standby transformer.

Main control room equipment: 1#,2#The main transformer protection measurement and control screen has one group each (the upper includes the operating box, the high voltage side, the medium voltage side, the low voltage side into the line protection device, the controller and the temperature controller. The controller is used to adjust the output voltage of the main transformer in gear).1# The operation box of the main transformer protection measurement and control screen is damaged, and it can not display the status of the main transformer switch in position and in position. microcomputer monitors the charging and feeding cabinet group of DC power supply (including charging monitoring module 1, charger module 3, control feeder switch, closing feeder switch, accident lighting, storage battery and AC feeder switch). The accident of high voltage cable head causes all damage of monitoring module and charger module. There are two groups of battery cabinets for DC power supply (108 batteries in total). AC screen group 1. Acting as AC to DC converter, supplying power to battery pack and lighting and socket of the whole station. Group 1 of watt-hour meter screen. Including two meters for Xiaoyu line, one for main line and one for Liangyu line. (There is also a tunnel watt-hour meter in Zhashui Substation). Communication screen group 1 is responsible for data transmission to the background computer. The equipment of communication room includes two groups of battery cabinet of communication power supply, one group of AC and DC distribution cabinet and one group of DC feeder cabinet. Mainly responsible for data transmission to the Zhushui Substation, which has not been activated at present.

#### *B. 10KV Equipment room: 1 Main Equipment, 2 Sets.*

The feeder cabinet supplies power to all the transformers along the way, through the voltage mutual arrester cabinet and bus isolation switch cabinet to the feeder cabinet. There are 6 feeders, 2 feeders are responsible for the single 10KV box in the tunnel, 2 feeders are responsible for the double 10KV box in the tunnel, 1 feeder for the South mouth rescue center, 1 feeder for the high-level water tank in the South mouth, the room under the bridge and the feeder cabinet. South mouth high pole lamp power supply. There are also reactor feeder cabinets and reactor cabinets. The coils of the two reactors were burnt out during operation and could not work normally.

#### *C. 5KV Equipment Room: 1 Main Equipment, 2 Sets.*

There are two feeders from the inlet cabinet to the voltage mutual arrester cabinet, then to the bus isolation cabinet, and to the feeder cabinet. They supply power to three shafts in the tunnel in the order of 3-2-1. There are also reactor feeder cabinets and reactor cabinets. The coils of the two reactors were burnt out during operation and could not work normally.

Fire fighting equipment of power supply station: The main control room and communication room are Fluorine propane automatic fire extinguishing system. The rest rooms are one cart fire extinguishing tank and two portable dry powder fire extinguishers (4kg).

5KV shaft substation. There are three shafts in the tunnel with a 35KV substation, which uses double circuit power supply. It is mainly responsible for the power supply of the shaft axial fan and the basic lighting in the shaft.

Shaft distribution room. Shaft power supply and distribution lines are transformed from 110 kV substation at the south entrance of the tunnel to 35 kV combined electrical appliances (including circuit breakers, buses, disconnectors, current, voltage transformers and lightning arresters) of Siemens, and then from Shanghai Huguang 35 kV transformer to 6 kV to ABB high voltage switchgear (line 1 to switch cabinet) to supply power to the converter cabinet, providing shafts. Internal lighting supply; 1 way to bus circuit breaker cabinet, capacitor cabinet connection. Axial air supply, exhaust fan cabinet and supply and exhaust spare cabinet of East-West line are supplied directly to start the axial fan of soft start cabinet. Two reactors were added to the 2# shaft in the distribution room.

Communication monitoring room. Communication cabinet, storage battery cabinet, AC screen monitoring and displaying of high frequency switching power supply, DC screen monitoring and controlling of battery charging and discharging fire room. There are 9 150LFluorine propane cylinders and automatic fire extinguishing devices, which are used to extinguish fire in distribution room, control room and capacitance room respectively, and 2 portable dry powder extinguishers (4kg).

Fan room. A total of 32 large-scale axial-flow fans are installed in the fan room of tunnel ventilation shaft, including 17 supply fans and 15 exhaust fans. The fan adopts direct transmission mode and the movable blade can be adjusted. Each shaft site can be operated locally by touch screen on the axial flow exhaust fan, and the axial flow fan can be operated locally on the fan side operating table.

#### *D. 10KV Box Transformer.*

There are 13 10KV substations in the tunnel. Each substation contains two transformers, which supply double-circuit power to lighting equipment, jet fan and monitoring equipment in the tunnel. Two reactors were added to 9 # and 12 # box transformers respectively.

One side box contains two transformer temperature controllers, two inlet cabinets, two capacitance compensation cabinets, four feeder cabinets (including lighting, jet fan, communication trunk, spare line modules, all drawer modules) and contact cabinets; the other side box is changed into four groups of fan control cabinets, EPS control cabinets and UPS control cabinets. EPS is a three-phase emergency power supply, which is in sleep under normal conditions. It mainly supplies power to emergency lighting and fire escape signs after power interruption. UPS is an uninterrupted power supply, which can last 10-30 minutes after power outage in order to save all kinds of data.

### V. SUMMARY

As the longest expressway tunnel in Asia, the Qinling Zhongnanshan Highway Tunnel has never had a major accident of safety responsibility and fire accident since it was operated for more than seven years. This is due to its perfect power supply system and the hard work of the staff. Further improvement of the power supply system of the tunnel is the basis for tunnel safety.

### REFERENCES

- [1] Li C, Liu H. Based on the Optical Fiber Communication Highway Tunnel Power Supply Backup Solution[J]. *Electrical Engineering*, 2017..
  - [2] Zhang Q C. Discussion on the Construction Technology of Power Supply in the Tunnel of the Special Long Tunnel[J]. *Telecom Power Technology*, 2017.
- Reference to a chapter in an edited book:
- [3] Guo J, Peng J, Xiao M. Technologies of high-voltage power supply for long tunnel in high-altitude locality[J]. *China Water Resources*, 2016..
  - [4] Wang B X. Design on Power Supply Scheme for Disaster Prevention and Rescue System inside Tunnels of South-Central Shanxi Railway[J]. *Electric Railway*, 2016.
  - [5] Lin B. Long Distance Transmission of Low Voltage Power Supply[J]. *Mechanical & Electrical Engineering Technology*, 2017.
  - [6] Liu L, Jian L I. Discussion on Key Technology of Traction Power Supply in Rail Transit Interconnection[J]. *Building Electricity*, 2016.