The Optimal Design of Main Electrical Connection in Railway Traction Substation

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Abstract
A variety of main connections in a traction substation are compared in technical performance, and a more suitable connection is elected. The capacity and the type of the main transformer are determined by the result of load calculation.

Keywords: Traction substation, Main electrical wiring, Selection of equipment.

Introduction
In this paper, we designed the wiring schemes of the main transformer for Zhengzhou railway traction substation. We choose four single-phase traction transformers (two operating, two spare). After the calculation of the traction transformer capacity, we know that what kind of traction transformer we should choose. Then, comparing the different main wiring schemes, the main wiring scheme design is determined also.

The characteristics of passenger railway traction power supply system
(1) When the train speed is in 300 ~ 350 km/h, the traction current can reach 600 ~ 1000 amperes, it requires a larger power supply capacity of the tractive power supply system;
(2) In the condition of high-speed, the train takes a short time getting through the power supply arm, which means that the duration of the load is short. At the same time, the number of trains in a power supply arm reduces accordingly, the load current fluctuation is volatile;
(3) Extending the power supply arm as far as possible, we can minimize the times of neutral section. Obviously, it is good for the train’s high-speed operation performance.

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(4) The characteristics of the traction load: when the volatility and amplitude changes a lot in different times, the demand for power is larger, the train can move fast and steadily.

**The classification of the traction power supply mode**

At present, countries around the world take the single-phase power frequency ac 25 KV power supply mode of electrified railway traction network, which mainly includes the AT power supply mode, DN power supply mode and BT power supply mode [1].

(1) DN power supply mode

The DN method increases the orbit-parallel overhead reflux lines that in the structure of direct power supply way, DN has advantages such as simply in the equipment, saving investment, quick& easy maneuverability, etc.

Before the AT power supply mode designed, we have to take the DN way used widely in electrified railway in our country because of its simple structure, but it does not have the very strong anti-interference ability.

(2) BT power supply mode

The BT power supply mode used BT transformer in electrified railway to lower the impact to the voice quality and the communication system stability.

BT can solve the problem of anti-interference, once be used widely in electrification project in our country. However, as a result of BT is concatenated in catenary, the pantograph was easy pulled arc when through catenary joints[2].In addition, its power supply ability is limited, so BT electrified railway power supply has not used in the last ten years.

(3) Auto transformer power supply mode (AT power supply mode)

The AT power supply mode is the autotransformer-paralleled in traction power supply system. The AT power supply mode reduces the interference with nearby communication lines, at the same time, it reduces the voltage loss of the traction network and expands the traction substation intervals. Because of the high voltage, large capacity and autotransformer needs to be installed on the along- line, so the investment for the traction network equipment will increase [3]. Practice has proved that the AT power supply mode is a kind of advanced way of power supply, which can effectively weaken the catenary induction effect of adjacent telecommunication lines, and adapt to high speed and high power electric locomotive running also.

Through the comparative analysis, this design chooses the AT power supply mode.
The basic requirements and design principles of the main electrical wiring

The basic requirements of the main electrical wiring:
(1) Reliability: in order to ensure continuous power supplying in various operation modes, the main wiring must be reliability;
(2) Flexibility: when corrective maintenance of electrical equipment is needed, design of the main electrical wiring operation should be convenient;
(3) Price efficiency: mainly reflected in three aspects: a small investment, less occupied area and small power loss;
(4) Security: ensure the safety of staff and electrical equipment in all operations.

The design principles of the main electrical wiring:
(1) Meets the requirements of the design specification;
(2) In accordance with the relevant guidelines, policies and technical specifications;
(3) According to the characteristics of the engineering, we must design the main wiring which does not cost a lot.

The choice of main electrical wiring
As an important part of the electrified railway power supply system, the traction substation plays the role of converting the three-phase ac high voltage to 27.5 kV (or 55 kV) and then meets the require of traction power supply [4].

The way of main electrical wiring is determined according to the specific conditions of traction substation. We take the power supplies and qualify as main body, when it goes in and out of the line more than four times, we often set the busbar to collection and distribution of electricity in order to make the wiring simple and clear and easy to operate.

(1) The preliminary selection of traction substation power supply side (220kV) of the main electrical wiring
According to the different location in the grid, degree of importance and the power to introduce, traction substation can be divided into different ways, such as:

**Center-location traction substation:** there are more than four routes into the line and power through systematic; we generally use mother line as main wiring;

**Passing type traction substation:** there are two routes into the line and power through systematic; in most cases, we use bridge connection generally;

**Tapping type traction substation:** there are two routes into the line, no system power passing through, it always takes the double T connection;

The Power through system refers to the substation busbar with other substation load going through.

Zhengzhou Railway Traction Substation and Zhengzhou Power Substation have two road three-phase 220 KV power line and into the equipment, it is the passing type traction substation. A preliminary selection comes out: bridge connection.

(2) The determination of the main electrical wiring traction substation with power supply side (220kV)
The bridge-connection takes the least number of circuit breaker connection: there are two kinds of bridge connection, inner-bridge connection and outside-bridge connection. Inner-bridge connection is suitable for long transmission line, more failure probability and in the situation of transformer does not need to be removed often. When the transformer goes wrong, the corresponding lines need to be cut off; outside-bridge connection is suitable for short transmission line, and in the condition that the transformer is often needs to be switched or the system has power lines be through. When circuit goes wrong, we need to stop running the corresponding transformer[5].

Due to the type of the Zhengzhou traction substation is the Passing Type Substation, considering the characteristics of large load and high speed of passenger dedicated line, the traction transformer often need to be operating, so we choose outside-bridge connection.

**The choice of traction transformer connection**

The characteristics of passenger dedicated line traction load are volatility, large amplitude changes. We should considering these characteristics when choosing traction transformer. There are two kinds of connection mode which are used by the passenger railway traction transformer; single-phase connection and V connections.

With the increasing number of electric locomotive, the traction load of passenger railway traction substation will gradually increase in our country at the same time. On the other hand, restricted by short circuit capacity increasing and the bearing ability negative sequence, using the single-phase connection of the traction transformer widely is difficult in recent times.

For V connection, V/X wiring pattern has prominent advantages. V/X transformer and V/V transformer structure are similar to that of the equivalent of two V/V transformers. V/X wiring traction transformer is three winding transformer, high voltage for a winding, low voltage have two windings T and F respectively. In the middle of the two winding grounding, when two such single-phase transformer gets together, we get a V/X wiring. V/X wiring is integrated the technology of V/V connection and the way of the AT pure single-phase connection. It is simpler in design and manufacturing compared with Scott and Cross Wiring. The capacity utilization rate of V/X wiring traction transformer is 100%, it can supply three-phase load within the substation and make the traction network the bilateral power supply.

Through the comparison, we choose the three-phase V/X wiring in the design and 2 x 27.5 kV system in the traction transformer secondary side.

**2 x 27.5 kV side feeder connection options**

According to the different standby way of feeder circuit breaker, there are three kinds of feeder connection mode:

- **Feeder circuit breaker 100% spare connection mode**: it always used in single sections and traction busbars in different phase, and each feeder circuit breaker is equipped with a backup circuit breaker.
Feeder circuit breaker 50% spare connection mode: it is used in the situation of single sections, and the traction busbar is in the same phase, if each phase busbar only has two feeder in the extension of double line segments, and setting up a backup breaker every two feeder circuit breaker. The breaker backup is realized by the transformation of the isolating switch.

With bypass bus and the bypass circuit breaker connection mode: using in the occasion of each phase traction busbar has more feeders. Every 2 ~ 4 article feeder has a bypass circuit breaker, thus, the bypass bus can make the bypass circuit breaker have the effect of standby.

In combination with the practical situation of Zhengzhou traction substation, we choose the feeder circuit breaker 50% spare wiring.

Construction scheme is the combination of the Zhengzhou traction substation construction and the Zhengzhou railroad distribution. In order to meet the needs of the reasonable utilization of resources and the safety of power supply; we delivered two private electricity transformers from the 10kv busbar.

The main wiring diagram of Zhengzhou traction substation drawing used CAD was shown in figure 1.

Figure 1. The main wiring diagram of Zhengzhou traction substation drawing.
Summary

The design uses AT power supply mode, three-phase V/X wiring. The AT power supply mode is the preferred way relative to the high speed and overloaded electrification section. The utilization of Three-phase V/X wiring traction transformer can reach 100%, And can supply three-phase load that within the substation and district, can realize the bilateral power supply for traction network.

REFERENCES