Characteristic Analysis of Transmission System Based on Traction of Double Current Electric Locomotive

Hongliang Guan

Jilin Railway Technology College, Jilin, Jilin, 132200, China

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Abstract: Electric Locomotive is a Double Current Ac Drive Electric Locomotive. It is Suitable for Ac 25kv / 50hz and Dc 3000v Power Systems. According to Different Power Specifications, the Locomotive Can Realize the Main Circuit Conversion under the Condition of Continuous Operation. This Paper Mainly Introduces the Design Principle of Grid side High Voltage Circuit and Traction Converter System as Well as the Locomotive Control System Function of Electric Locomotive Electric Traction System, and Analyzes the Main Elements and Technical Characteristics of the Design.

1. Introduction

Due to Historical Reasons, Many Countries in the World Have Multiple Power Systems in Their Railway Systems. in the Early Stage of Main Railways, Low-Voltage Dc Power Supply is Mostly Used, and in the Past 50 Years, High-Voltage Ac Power Supply is Mostly Used, While in Urban Railway Transportation, Low-Voltage Dc Power Supply is Generally Used[1]. Therefore, in Many Countries and Regions, They Are Faced with the Transmission Problem of the Whole Power System to Varying Degrees. At Present, There Are Four Main Power Systems: Ac 15kv / 16.7hz, Ac 25kv / 50hz, Dc 1500v and Dc 3000v. Electric Locomotives Are Exported to South Africa from Two Mobile Narrow Gauge Electric Locomotives, Crrc. Compared with the Ac Drive Electric Locomotive Widely Used in China, the Electric Locomotive Has the Function of Working under the Ac 25kv and Dc 3000v Power Systems. Wireless Data Transmission and Other Functions This Paper Introduces the Electric Traction Control System of Double Current Electric Locomotive.

2. Main Technical Parameters of Locomotive

Under the Ac Power System and Dc Power System, the Locomotive Adopts the Unified Design of Traction and Electric Braking Characteristics, with a Wide Power Interval[2]. the Locomotive Adopts High-Precision Speed Sampling and Traction Output Control. When the Train is Loaded, It Can Make the Low-Speed Constant Speed Control Mode Run At a Certain Speed within the Speed Range of 0.2 ~ 3km / h, the Step-by-Step Adjustment Range is 0.02 Km / h, and the Speed Change is Less Than 10% of the Set Speed. the Locomotive Has Different Power Performance Curves in Ac Power System and Dc Power System. the Power Supply of Auxiliary System is Not Limited to the Allowable Variation Range of Network Voltage.

In the 25 kV / 50 Hz power supply system, when the network voltage is 22.5 ~ 29 kV, the power around the wheel is 3000 kW, from the network voltage of 22.5 kV to 19 kV, the linearity of 2520 kW (84% of the rated power) around the wheel is reduced, and the network voltage from 19 kV to 17 kV is reduced. The wheel power is reduced to 0 in a straight line[3]. When the network voltage increases from 29kv to 31kv, the wheel power decreases to 0 in a straight line, exceeding 31kv over-voltage protection. In the 3000 V DC power system, the network voltage is in the range of 2.8 ~ 3.9 kV, and the wheel power is 3000 kW. When the network voltage is reduced from 2.7 kV to 2 kV, the wheel power is reduced to 0 in a straight line, which is lower than the pressure protection of 2 kV. When the network voltage rises from 3.9 kV to 4 kV, the wheel power drops to 0 in a straight line, and the over-voltage protection exceeds 4 kV.

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3. Traction Electrical System

The traction power supply system is composed of grid high voltage circuit and traction converter system circuit[4]. The grid side high-voltage circuit completes the selection of the power system, receives the current, and the traction converter system circuit completes the energy conversion.

3.1 High Voltage Circuit At Network side

Corresponding to different power systems, the locomotive has two circuit configuration modes. Under the condition of working in AC power mode, the AC / DC selective circuit breaker (YS 2) is in the cut-off position, the AC main circuit breaker (YF 1) is closed, and the traction transformer is used as the voltage conversion device of power grid[5]. The DC selector disconnector (YS 2) is in the closed position, the AC main circuit breaker (YF 1) is open, the DC main circuit breaker (YF 2) is closed, and the secondary coil of the traction transformer is used as the DC filter reactor. The PRMA 3U 15, Br 189 and Rh 1216 series locomotives in Europe have slight differences due to different traction converter system circuits of the same design.

3.2 Dc Filter Circuit

In DC mode, the locomotive reconfigures the main circuit. The main circuit includes a DC filter reactor composed of LSand secondary winding of traction transformer. The selection of DC filter connector mainly considers the following factors.

(1)Short circuit current suppression capability in case of short circuit fault of main circuit

(2) Over voltage generated in operation

(3)Matching with capacitors in the main circuit;

(4) Constant impedance parameter of solid line

(5) Nuclear reactor weight, volume and other factors.

The parameters of the substation show that the equivalent inductance of the power supply source is L = 0.9 MH, and the resistance is r = 0.11. When the locomotive is near the power supply station, grid line impedance is not considered. Fig. 5 shows the equivalent circuit of the system. R1 and R2 are equivalent resistances of locomotive lines and devices, LS and LTR are filter reactors, and CD are supporting capacitors of locomotive traction converters.

When the voltage of power supply network is DC 3000V, the inductance of DC filter is 6,26mh, the traction converter works at full load, simulating the short circuit of DC circuit. The analog waveform is shown[6]. Within 30 ms after the short circuit, from the simulation results, the current increase rate is about 295,88 A / Ms. when the locomotive main circuit is short circuit fault, the larger the DC value is, the higher the short circuit current increase rate will be. The maximum response time of the lower system can be calculated by equivalent circuit simulation, which provides the basis for the selection of high voltage electrical components and the setting of protection parameters. The increase rate of short-circuit current is 100 a / Ms. it is assumed that the main circuit breaker and DC circuit breaker should be cut off when the short-circuit current reaches 3000 ~ 4000 A. after that, the hardware control loop must be completed within 20 ~ 30 ms for voltage and current detection and breaker cut-off action. If the requirement is high, it is necessary to design intermittent device to make the control coil of DC main isolator lose power quickly and accelerate the failure process.

When the voltage of the power supply network is DC 3000V, the DC inductance is 6,26mh, and the traction converter works at full load, simulate and calculate the sudden blocking pulse condition of the traction converter[7]. The analog waveform is shown in Fig. 7. In a short time, the intermediate voltage UD rises to 3798v and 4407v. The simulation test results show that if the locomotive traction converter suddenly cuts off the pulse under the traction condition, the intermediate voltage will rise sharply, which may exceed the allowable working voltage of the traction converter[8]. In particular, the upper limit of working voltage of DC grid is 3.9 ~ 4KV. In this state, over-voltage will deteriorate. Therefore, even if the main circuit has an over-voltage protection device, it is not necessary to increase the inductance of the DC filter through the detection / opening process of the device.

Because the 50 Hz AC module exists in the power circuit of the existing lines in South Africa and may cause interference with the signal system, there are specific requirements for locomotive impedance at this frequency. The design can be considered comprehensively according to the actual conditions of the line and the locomotive formation. The equivalent simplified circuit of 50 Hz AC component path in locomotive DC mode is shown.

In addition, too small inductance of the filter will cause the current of the short circuit to rise too fast and threaten the system protection. Opportunities greatly increase the difficulty of design. In addition, special necessary conditions, such as suppression of line signal interference, may also be included. Therefore, the selection and selection of filter reactor are the result of comprehensive consideration and repeated demonstration.

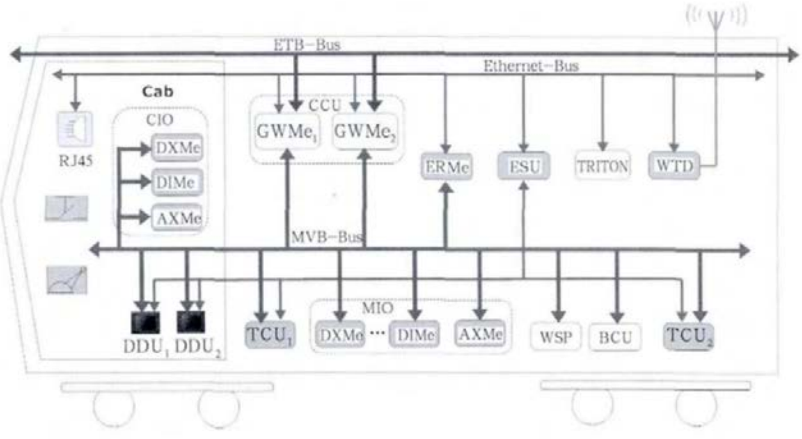

Fig.1 Locomotive Network Control System Topology

3.3 Traction Converter System

The locomotive traction converter system is mainly composed of traction transformer, two traction converters and four asynchronous traction motors. Each traction converter is equipped with a dual four quadrant rectifier. Moreover, it corresponds to two secondary windings of the traction transformer (each traction transformer has 4 secondary windings)[9]. Two sets of inverters correspond to two asynchronous traction motors, which are used to control the axial direction. One of the first and second intermediate DC circuits is connected in parallel. The secondary resonant capacitor of the intermediate DC circuit is connected in series with the secondary resonant reactor set in the traction transformer to form the secondary resonant circuit. When the locomotive works in the AC power area and under the traction condition, the grid side voltage enters the primary winding of the traction transformer from the histogram of the AC main circuit breaker. After the voltage is reduced, it is output through the secondary winding and enters into the traction converter for cross DC-AC conversion, and finally drives the asynchronous motor. Under braking condition and generator condition, the electric energy generated by the working asynchronous motor is fed back to the grid passing through the traction transformer. When the locomotive is running in the DC power area, under the traction condition, the AC / DC selective separation switch (ZS2) of the locomotive is closed, and the AC / DC conversion separation switch ys 1.1, ys 1.3 and ys 1.6 of the traction converter are open. QS 1.2, QS 1.4, and QS 1.5 are turned off.

The grid side voltage enters the DC circuit through the filter reactor from the board diagram through the DC main circuit breaker. The DC voltage is carried out by the inverter in the braking mode, and the electric energy generated by the asynchronous motor working in the generator mode is fed back to the grid or consumed by the braking resistor. The traction converter adopts the integrated design of main and auxiliary. The primary and secondary DC circuits inside the traction converter are connected in parallel to supply power to the parallel converter. The auxiliary power system adopts redundancy design. Under normal conditions, VVVF and CVCF power can be provided to the auxiliary system respectively. When one auxiliary converter fails, the other auxiliary converter can maintain the power supply of the locomotive auxiliary system. At this time, the auxiliary converter works in CVCF mode.

4. Conclusion

According to the results of rolling stock transmission test and long-distance front-line operation, it can run stably under traction, braking control, reconnection control, system phase separation control and other conditions. Bonding control and other aspects show excellent performance, which shows that the electric traction and control system can fully meet the requirements of vehicle design. The self-propelled double current electric traction control system has broken the technical bottleneck of the multi current locomotive, gained the opportunity to compete with foreign advanced technology, and played a good role in expanding the overseas market of Chinese locomotives.

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