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Development of Electric Drive System and Its Control for Urban Rail Vehicles

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Abstract: Sustainable Development is the Theme of Today's Social and Human Development, and Low-Carbon Transportation is One of the Major Measures in the Concept of Sustainable Development, and It is Also a Key Research and Development and Attention Topic for Transportation Development in Various Countries Around the World. in the Process of Vigorously Developing Urban Rail Transit, the Use of Electric Power and Hybrid Design to Drive the Operation of Rail Transit is Currently the Focus of Our Research. Electric Drive and Hybrid Drive Have Been Widely Promoted and Applied on Urban Buses, But in There Are Relatively Few Applications in the Development of Urban Rail Transit, and There is Still Great Development Potential. in the Context of the Rapid Development of Urban Rail Transit in China, It is of Great Significance to Continuously Research the Electric Transmission Related Technologies of Urban Rail Transit to Develop and Improve the Traction Drive System of Urban Rail Transit.

1. Introduction

The development of China's rail transit originated in the 1950s. After decades of development, rail transit has gradually grown. In the 1950s, China successively built the Beijing subway network and the Shanghai subway network, accumulating a lot of experience, and then launched a series of subway network construction projects throughout the country. After entering the 21st century, with the rapid growth of the urban population and the acceleration of the industrialization process, people's requirements for living comfort and convenience have continued to increase, leading to a sharp increase in the number of private cars, increasing exhaust emissions from cars, and increasing urban traffic congestion The problems of urban pollution and noise pollution have also become increasingly serious. In this context, people's awareness of protecting the environment is getting higher and higher, and economic and social development cannot be separated from the protection of the natural environment. Economic and social development cannot be exchanged at the expense of the environment. Therefore, effective measures have been taken throughout the country to improve The city's transportation capacity reduces the number of private car trips and meets people's requirements for fast travel. Green, energy-saving and environmentally friendly rail transit has become the first choice for the construction of a new type of environmentally friendly city, which has also effectively promoted the development and application of urban rail transit-related technologies. Among them, the urban rail electric drive technology is constantly updated and replaced from DC speed to AC speed stage.

2. Development of Electric Drive Systems

Urban rail transit relies on tracks and vehicles. Traffic vehicles are driven on the tracks under the control of the electrical system. Therefore, the safety and reliability of the electrical system is closely related to the safe driving of the transportation vehicles on the tracks. Its technical level will reflect the quality of rail vehicles. According to the difference of the electric system motor, it can be divided into DC drive and AC drive. DC traction motors make operation simple at the expense of complex structure. The AC asynchronous motor is completely the opposite. Its structure is relatively simple, but it is extremely complicated to perform a wide range and high-performance variable-speed operation. The semi-controlled thyristor (SCR) played a very important role in the development of DC drive. At that time, the electrical system of AC drive had been developed in

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Germany and applied to the subway manufacturing industry. The emergence of thyristors that can be turned off has promoted the development of AC drive electrical systems with variable voltage and frequency conversion. The rapid development of AC drive makes advanced western countries stop manufacturing DC drive vehicles. GTO and BJT, the current-driven fully-controlled power electronic devices, have gradually been replaced by voltage-controlled fully-controlled devices (GBO and IPM). GBO and IPM also perform better than GTO and BJT. In foreign subway manufacturing, IGBT modules have also replaced the original GTO devices. From this point, it can be seen that the excellent performance of IGBT modules has been widely recognized and applied in auxiliary power systems and main drive systems.

3. Development of Traction Converters

When the initial voltage strength was low, some countries used 1 200 V and 1 700 V IGBTs to form three-point (three-level) inverters for 750 V and 1 500 V grids. With the development of science and technology, the IGBT module under high voltage has the conditions for manufacturing and practical application, and it can be better applied to the two-point inverter under the 1 500 V power grid. Therefore, at the end of the 20th century, many subway manufacturing companies adopted this technology for the manufacture of subways and light rails. In addition, three-level inverters are also being produced. Although this inverter has better output waveforms and smaller voltage changes, due to problems such as high manufacturing costs and complex main circuits, the frequency of use is much lower than Two-level inverter.

The characteristics of rail vehicles determine the use of compact, lightweight and small devices, so insulated IGBT modules have even more advantages. At the same time, the application of low-inductance bus technology reduces the parasitic inductance of the bus to reduce the peak voltage at the time of the disconnection, so that the inverter can cancel the absorption circuit. The technology can keep the peak voltage of the inverter under 1 500 V grid voltage below 2 300 V.

Traction converters use the form of variable frequency and variable frequency to achieve the purpose of variable speed, which is called a variable frequency inverter (VVVF). The control methods for controlling the speed by pulse width include: high-frequency and low-frequency global asynchronous control methods, low-frequency asynchronous and synchronous control methods, and asynchronous expansion control methods. At present, the most commonly used AC drive system is rotary vector control or direct torque control. The normal work of this type of control depends on the feedback information of the motor speed. And the performance can be more stable, very suitable for the electric drive system of modern rail vehicles. The currently used rail vehicle parking systems are generally completed by pneumatics, and this method will vary depending on the speed of the rail vehicle. When driving at low speed, instability due to braking will occur, and vibration will occur, reducing comfort. The latest parking method by electric braking does not need to consider these problems at all. It can improve the parking accuracy without causing passengers to feel a shock and the entire braking process will not generate noise. These excellent performances It will be easier for passengers to get approval and improve comfort.

4. Modern Control Theory and Ac Motor Control

The AC motor and the inverter are a non-linear multi-variable system. Based on the modern control theory of state space and state equations, it plays a classic control in solving the control problems of non-linear multi-variable systems with uncertainty and cannot be accurately described The power of theory is hard to work. Here we mainly introduce adaptive control and intelligent control. Adaptive control is based on the linear extraction of execution object information and forces the control system to adapt to the operating conditions of the object. It is a system that combines a parameter recognition algorithm with a suitable controller. It uses a stochastic process algorithm, which enables a large class of practical systems to obtain good calibration and control performance. As a linear time-varying system, two types of motors are self-tuning adaptive and model reference adaptive control. Intelligent control applied to AC drive system is to make full use of various functions such as intelligent control nonlinearity, variable structure, and self-optimization to overcome disadvantages such as variable parameters and nonlinearity of the AC drive system, thereby improving the robustness of the system. At present, the more mature intelligent controls in the application of AC drive systems are fuzzy control and neural network control. The fuzzy logic control method is used for vague or uncertain systems. It uses the concept of membership function to deal with some control problems, such as non-linearity, load disturbance and parameter changes. A neural network is a method of computing and information processing that imitates physiological neural units. The relationship between its two basic units (neurons) is defined as weights, which can be adjusted and trained offline and modified online.

5. Control Chip Technology and Locomotive Network Control

Modern AC drive systems require high-precision control, and the requirements for micro-processing chips are becoming higher and higher: the chip should have sufficient word length and data type; the algorithm specified in the design is calculated within the system sampling period; the capacity of the memory and the chip Addressing ability fully meets the requirements of the algorithm; 10 ~ 12-bit A / D converter and PWM output port with fast enough conversion speed; good interrupt ability; excellent timer group; good communication function and network function CAN field bus is used as the basis for local control network connection). In the 1980s, Inte18086CPU and DECIxPD 7720DSP combined to complete the field-oriented vector control AC drive control system, which greatly promoted the application of DSP chips in AC drive computer control. Subsequently, Texas Instruments' TMS32010 DSP chip completed low-power direct torque control. system. In the 1990s, chip performance was further improved, TMS320C25 and TMS320C30 appeared, floating-point computing capabilities were enhanced, and accurate state estimation became possible. Speed sensorless magnetic field directional control commercial inverters were developed, but at the time DSP chips could not fully meet the requirements of electrical drive control. need. Until TI launched TMS320C14, the motor-specific microcontroller integrated functional modules required for real-time control, such as excellent timers, high-speed I / O ports, strong-function interrupt controllers, and high-speed, high-precision multi-channel A / D converter, multi-phase PWM waveform output, etc. In recent years, TI has launched the 32-bit digital signal processor TMS320C28x series. The main frequency has been increased to 150 MHz, and the execution speed has also reached 150 MIPS. The A / D conversion necessary for motor control has been increased from 10 bits to 12 bits of TMS320C240. It also has excellent configurations such as interfaces to external memories and modules connected to the fieldbus CAN. It can be seen that the AC drive control chip is gradually developing towards specialization and networking, which also lays the technical foundation for the computerized and networked drive control. As a key technology of modern trains, network control technology has been rapidly developed and applied. The world's major rolling stock manufacturers have launched network-based control systems, such as Siemens' SIBAS32 railway automation system, Bombardier's MITRAC train communication and control system, Alstom's A-GATE control system, and Mitsubishi and Toshiba's TCMS Train control and monitoring system. In addition, WordFIP bus, Lonworks bus, CAN / CANopen bus, etc. have also been widely used in train control networks. In 1999, the IEC International Standardization Organization adopted the TCN train network international standard of IEC61375-1 to solve the problem of interoperability between trains and on-board control equipment, thereby minimizing the development, production, operation and maintenance of train control systems. Cost, to ensure the best interests of customers. TCN is positioned in a two-layer topology with a twisted-pair train bus (WTB) connected to a multi-purpose vehicle bus (MVB). The vehicle bus is based on the MICAS vehicle bus MVB. The train bus is based on the experience of using DIN43322 and CD450. The standards of China's Ministry of Railways use T-type and L-type networks. The T-type network has fast transmission speeds and short distances, which is suitable for non-fixed marshalling trains, or occasions with high real-time requirements, certain transmission time requirements, and tight time limits; L-type The network transmission speed is slow and the distance can reach 2.7 km. It is suitable for long-distance fixed marshalling trains with a small amount of data to be transmitted and less time-critical. Due to the advantages and disadvantages of different control networks, there is currently no control network that fully meets all the needs of railway users. Therefore, the development trend of train control networks is that multiple network technologies coexist, compete with each other, and multiple networks are compatible and coexist in a large system. Case. In addition, with the advancement of industrial Ethernet technology, it may become a new force in train control networks.

6. Conclusion

The construction of urban rail transit makes people's travel more convenient. It can greatly alleviate the problem of traffic congestion in cities and enable people to have convenient and fast transportation. The construction of urban rail transit must be completed on the basis of sufficient technology, and the electrical system is the most important one. With the development of science and technology, the research and development of rail vehicles will gradually deepen, which will guarantee the development of urban rail transit. In addition, in order to promote the development of urban rail transit more quickly, its researchers must take a lot of practice, combined with China's national conditions, to develop a new type of urban rail transit with high technological content and low energy consumption and green in practical applications. Technology has contributed to China's better and faster development.

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