

The opportunities and challenges of urban power network by intensive urban rail transit

Bo Jiang¹, Qi Jiang^{2,a}, Yan Li¹ and Wenbo Zhu¹

¹ State Grid Xi'an Electric Power Company, 710032 Shaan'Xi Xi'an, China

² State Grid Shaanxi Electric Power Company Training Centre, 710032 Shaan'Xi Xi'an, China

Abstract. Driven by the demand side, transportation industry is undergoing new changes. Intelligent comprehensive transportation system, becoming the focus of city development and ushering in the outbreak period, is an important part of urban rail transit, with large capacity, environmental protection, safety, etc. This paper introduces the development of urban rail transit in recent years, puts forward the opportunities for urban power grid development based on the research on the structure of the power supply system of urban rail transit in our country. And combined with the actual situation of our country, puts forward preventive measures about the impact of urban power grid.

Keywords: rail transit; urban power grid; wire and cable.

1 Introduction

With the development of the economic level of the whole country, the demand for the railway transportation is growing dramatically. Railway track lines and the channel, East and West, North and south, now get into a large-scale construction stage, but due to the impact of long distance, complex geographical environment, the railway's power transmission system and line materials put forward higher standards. Which is demonstrating that the railway track construction will boost China's wire and cable industry and promote the role of the executive meeting of the State Council to strengthen the deployment of urban infrastructure. In the face of the challenges of urban development and infrastructure construction, the State Council executive meeting "suit the remedy to the case": strengthen the large capacity public transportation system construction such as subway and light rail, enhance the connectivity and accessibility of the cohesion of the urban road network and convenience of the degree. Liu Lifeng, a researcher of Macroeconomic Research Institute of national development and Reform Commission, pointed out that, in accordance with the provisions of the national development and Reform Commission, a city would like to build the subway, the number of its population, GDP and fiscal revenue, etc. must be up to the standard. With the accelerated process of urbanization, more and more cities will reach the standards, so rail transit construction has great investment potential. Therefore, the demand of track traffic for the locomotive cable, communication and signal cable will increase further.

^a Corresponding author : duanlaiyue@126.com

2 The development of urban rail transit in China

Compared with other urban public transportation, urban rail transit system has its advantages of safety, comfort, environmental protection, large capacity and less energy consumption. With the continuous expansion of economic development and the size of cities, urban rail transit construction of our country entered into a stage of rapid development. As of the end of 2008, China has 10 cities with a total of 29 of urban rail transit lines in operation, the operating mileage reached 776 kilometers. Besides Beijing, Shanghai, Chengdu, Xi'an, Shenyang, 15 cities total about 50 lines, about 1154 km are under construction. And in recent time, about 22 urban rail transit construction plans have been approved by the State Council. To 2015, 22 cities, such as Beijing, Shanghai, and Guangzhou will build 79 of rail transit lines, with a total length of 2259.84 km. Which also means that by 2015, China's Built and under construction of rail lines will reach 158, the total mileage will exceed 4189 km.[1]

From the project has been built and plans of the construction, according to the technology of traffic of development trends and different demand for transport capacity, China will form many types of rail transit system to meet the demand of the traffic in the city; and introduce the technology of modern control, modern communication and modern network, which make the rail transit play a greater role in urban traffic, more safety assurance, service level continues to increase. Rail transportation in our country has a large capacity of subway system, urban elevated rail transit system, elevated monorail system and low volume of ground light rail system, in addition to high-speed maglev system, rapid suburban railway system and so on. The existing six cities (Beijing, Shanghai, Guangzhou, Tianjin, Shenzhen, Nanjing) own and are building the subway, four cities (Beijing, Shanghai, Wuhan, and Chongqing) have constructed elevated rail transit system, Tianjin, Dalian City have constructed suburban railway, Changchun City has constructed the light rail on the ground, Shanghai city has built a high-speed maglev system, Beijing and Guangzhou are planning to construct the linear motor system.[2]

3 The composition of urban rail transit power supply system

Urban rail transit operation mainly consume electrical power, including traction power and a variety of lighting power. Traction power supply system is the key to power supply system of urban rail transit (hereinafter referred to as urban rail), and traction power supply system generally adopts DC traction power supply system, China's national standard for DC 750V, 1500V. Traction power supply system such as shown in Figure 1, the power plant send the power to the traction substation through the three-phase voltage AC line which is often referred to external power. External power points for centralized and decentralized two power supply. Traction substation make the external power supply to buck, rectify then drive electric locomotive through the contact network, return line, this part of the power supply line is often referred to the traction network. Contact network is divided into overhead contact line and the contact rail. For example, the Beijing subway is 750V DC third rail contact system decentralized power supply mode, and Shanghai, Guangzhou, adopt the 1500V overhead contact network system centralized power supply.

4 The urban rail transit in urban power grid development opportunities

4.1 city electricity consumption growth

Urban rail transit construction will drive the surrounding areas of the power supply load increased significantly. Power supply load in Xi'an, for example, northern suburb area of nearly 30000 kilowatts, predicted in 2010, northern suburb area power load will reach 90000 kilowatts, in 2015 will reach 2015 kilowatts, in 2020 will reach 300000 kilowatts. After all six subway line was put into operation, the subway power load will account for one 7 of the city's electricity load, largest and most important

be xi 'an electricity load. Construction of urban rail transit in our country electrified railway, 4000 km of new electricity installed capacity of 5.5 million kw and 110 kv, 220 kv substation and line, the construction of the power supply system of electrified railway and related will also enter a new period.

4.2 wire and cable enterprise rapid development

Though urban rail transit is one of the city's largest infrastructure, wire and cable are the main artery and lifeline of the rail transit, whether it is the transmission of power or information, can't be separated from the wire and cable.

Under the influence of these factors, it is expected that domestic transport demand will maintain steady growth. Rail transport to improve traffic capacity, ease traffic congestion has been valued by the government, the industry is expected to accelerate the development of urban rail transport further in China. Liu Lifeng, a researcher of Macroeconomic Research Institute of national development and Reform Commission, pointed out that, in accordance with the provisions of the national development and Reform Commission, a city would like to build the subway, the number of its population, GDP and fiscal revenue, etc. must be up to the standard. With the accelerated process of urbanization, more and more cities will reach the standards, so rail transit construction has great investment potential. Therefore, the demand of track traffic for the locomotive cable, communication and signal cable will increase further.

5 The challenge of urban rail transit in urban power grid

5.1The security of the power supply system

Power supply system of urban rail transit asked to meet the different requirements of the train and dynamic lighting electrical equipment for the power, with sufficient safety and reliability, to ensure the power supply system can be safe and stable operation of power supply in normal operation, to deal with the accident, disaster relief and other complex conditions. Traction load is first level load, and power lighting loads are for first level, secondary and tertiary load. The first level load should be supplied by the double power and double circuit, when one power failure occurs, the other one should not damaged simultaneously. Two power supply lines are reserved for each other, one way out of operation, the other way should be to bear the power supply to the first level and the secondary load, and its technical indicators shall not reduce. It's linear that the distribution of urban rail traffic load along with the urban rail transit line. Which requires that the position of the main substation can only be along with the urban rail transit, and it's better to set the location of the substation near to the rail line. And it is often densely populated areas that near the line, so the urban rail transit substation should be as far as possible to choose a small area of the substation equipment.

5.2 Influence the power quality of power supply system

Besides the main traction rectifier units, there is nonlinear load and a large number of fluorescent lamp, inverter and soft start device in the rail transit power supply system. These devices produce certain harmonics, cause the sine waveform distortion of the power system and power quality decline. In order to reduce the influence of the harmonic current of traction power supply system on the original urban power grid, the corresponding measures must be taken to reduce the harm of harmonic and the possible hidden danger. [3]

The harmonic of electric locomotive is the power system of the transformer, which is through the contact network and the traction substation. The contact network should be considered in the distribution parameters, which will affect the harmonic content of the power system. As the location of the locomotive is different, the influence is different. Electric railway traction load in addition to produce a large number of harmonics, but also produce large negative sequence component, the power

system have adverse effects for some equipment.

5.2.1 The influence of the machine

Harmonics will generate additional losses, result in mechanical vibration, noise and harmonic over-voltage, so that the life of the motor is reduced. In addition, when the negative sequence impedance is very small, the negative sequence voltage will generate a large negative sequence current. Reverse rotating magnetic field generated by the negative sequence current in the stator winding, vortex in the rotor core laminations, causing increasing iron loss, heat to the rotor, and generates a reverse braking torque, reduced motor output and overload capacity.

5.2.2 The impact on the transformer

The all star-type transformer, when the neutral point grounding, power grid distribution capacitance is larger or with neutral point of shunt capacitor, may constitute the third harmonic resonance condition, resulting in the increasing of the third harmonic voltage, excitation current and the additional loss, which may cause the serious impact on the transformer for the safe operation. In addition, when the harmonic resonance condition is satisfied, the transformer may be damaged. Harmonic currents not only may cause the shell and some fasteners heat, but also cause the noise. [4]

5.2.3 The influence of cables and the effect of transmission line

The distribution capacitance of the cable to the ground is large, the high order harmonic current is easy to flow. In the low load of the power grid, the grid voltage is higher, causing the increasing of the harmonic voltage and the harmonic current flowing through the cable, so that the cable fault can be easily. Oil impregnated partial discharge the increase of dielectric loss and temperature rise are the main reasons of causing damage to the cable. In addition, much harmonic current (over 10A) can significantly delay the extinction of the secondary arc current, resulting in the failure of the reclosing, or cannot use the automatic reclosing of short delay.

5.2.4 Interference with communication

It may affect the definition of the communication or the safety of equipment and personnel when it is seriously damaged. The lower the frequency of communication signals, the more serious the impact is.

5.2.5 The impact on the power transmission

Harmonic current in power grid flow will produce active power loss, which is a part of the grid's power loss, and bad for economic operation of power grid. The negative sequence current will increase the grid loss.

5.2.6 Influence on relay protection and automatic device

Relay protection and automatic device initiated by the negative sequence current and negative sequence voltage, such as the negative sequence current protection, compound voltage lockout over current protection, distance protection oscillation locking device and recording device, may enable the malfunction, due to the electric locomotive produce larger negative sequence current and negative sequence voltage, Traction transformer or lead wire protection is often mistakenly started, recorder frequently recorded waves. Therefore, in order to reduce the false start, had to improve the protection set value, so as to reduce its sensitivity. The starting value of the recording device in Jiangbei, Hengkou, Guanmiao, and many other substation is very high. In addition, capacitor will damage due

to higher harmonic and large harmonic currents will delay or prevent fire arc suppression coil arc extinguishing effect, reduce the switch interruption capacity. [5]

6 Harmonic control measures

For the harmonic generated in the low voltage power distribution system of urban rail transit, we can mainly govern this from the following two aspects, and we will analyze one by one.

The first is passive mode, because the traditional distribution system of single capacitor harmonic amplification to several times the original or even dozens of times, because we need to adjusted single capacitor, the method adopted can series reactor in the reactive power compensation device, and absorb part of the harmonic through the parameter selected device. This method has very obvious advantages, such as high economic benefit, less capital investment, relatively simple structure, convenient maintenance. Although there are a lot of advantages in this kind of mode, the filtering characteristics are determined by the system and the filter, so there are four shortcomings, should pay more attention to while using. First, the filtering characteristics are greatly influenced by the parameters.; Second, harmonics can't be completely eliminated, only part of them; Third, when the current increases generated by harmonic, the filter's load will increase, which may result in instability of the system; Fourth, the use of this approach requires a lot of material, and the volume is very large.[6]

The second is the active mode. Based on the disadvantages of the passive mode, we have created the active mode, that is, we have applied the modern science and technology to complete the transition from the passive filter to the active filter. Compared with the passive filter, the controllability of the active filter is very high, and the reaction rate is very fast. It can compensate the harmonics of each time effectively in a very short time. The development of active harmonic governance is based on the passive filter and its filtering effect is far better than traditional equipment. as long as the power within the limits, harmonics can be completely filtered out. Its components include electronic components. The current generated in circuit has the same frequency and amplitude with harmonic, but in the opposite direction, so can Mutual offset. Equipment production of active control is complex, and the cost is very high. Its main application scope is the power supply system of the computer control system, the computer control power supply system of the factory, but it is not suitable to single machine. According to the related research, there are three main features of the active filter, First, the characteristics are not affected by the impedance of the system, therefore, the line will also lift the resonance; Second, the self regulating function of the device is very powerful, and can automatically track and compensate the harmonics in the change; Third, it can effectively restrain the resonance of the harmonic. The advantage of the active mode is more obvious than the passive, so we need to promote the use of a large range.

7 Conclusion

The construction of urban rail transit in our country must have a strong power supply system as a guarantee, the city rail power supply system to the power supply system construction put forward higher requirements. The advanced equipment of high reliability, intelligence and miniaturization will be widely used in the urban rail power supply system, which provides a broad space for the development of relevant enterprises and scientific research units.

It should take the view of overall plan to that the characteristics of related equipment such as each type of urban rail transit system, models, power supply mode should be studied in a specific environment, in order to analyze the adaptability of each urban rail transit system."Should take the development of vision, scientific approach, planning and constructing the urban rail transit which adapts to social development".

References

1. XZ Xu, BC Chen. Pacific Asia Conference on Circuits, Communications and Systems (PACCS '09). 310- 313(2009).
2. Baseri M.A.A., Nezhad M.N., Sandidzadeh M.A..Coxnpensating procedures for power quality amplification of AC electrified railway systems using FACTS[C]. Power Electronics, Drive Systems and Technologies Conference (PEDSTC). 518-521(2011).
3. Zaeim, R., Khoshkholgh, 2010 International Congress on Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT). 478-484(2010).
4. F Li, ZY Yang. Analysis and management research on the impact of Shanghai-Nanjing intercity railway traction load on power grid [C]. China International Conference on Electricity Distribution (CICED). 1-6(2010).
5. YQ Liu, GP Wu, HS Hua, L Wang. Research for the effects of high-speed electrified railway traction load on power quality [C]. International Conference on Electric Utility Deregulation and Restructuring and Power Technologies. 569-573(2011).
6. Hiroaki Morimoto, Masato Ando, Yoshifumi Mochinaga. Power Conversion Conference, Osaka. **3**, 1108-1111(2002).