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Impact of Intelligent Equipment on Construction of Technical Regulations System of Beijing-Zhangjiakou High-Speed Railway

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ABSTRACT
Due to the application of intelligent equipment, the existing technical regulations of high-speed railway cannot be applied to Beijing- Zhangjiakou high-speed railway. The existing intelligent equipment used in urban railway and high-speed railway applications is compared. The new equipment used in the construction and operation of Beijing-Zhangjiakou high-speed railway is analysed. On this basis, the impact of various equipment on the existing operation process of high-speed railway and its adaptability to relevant technical regulations are summarized. The results can provide reference for the revision of technical regulations of intelligent high-speed railway.

Keywords: *Beijing-Zhangjiakou high-speed railway, Intelligent equipment, Technical regulation, Impact analysis.*

1. INTRODUCTION

Beijing-Zhangjiakou high-speed railway is the first intelligent high-speed railway line in China, and it is also the latest achievement of intelligent railway development. It has been officially operated at the end of 2019. A large number of intelligent equipment was used in the construction process. The use of these equipment will have a certain impact on organization of train operation, equipment maintenance and passenger service. Existing regulations may not be applicable to new intelligent railway lines. Therefore, it is necessary to modify the old technical regulations and build a new intelligent Beijing Zhang technical regulations system. Figure 1 is the construction process of technical regulation system of intelligent Beijing-Zhangjiakou high-speed railway.

At present, intelligent equipment is widely used in the field of rail transit. Based on the application of existing rail transit field, this paper further analyses the differences of Beijing-Zhangjiakou high-speed railway equipment. Combined with the impact of various equipment on transport services, the adaptability of existing technical regulations is analysed. The analysis results can provide theoretical and technical support for future intelligent operation.

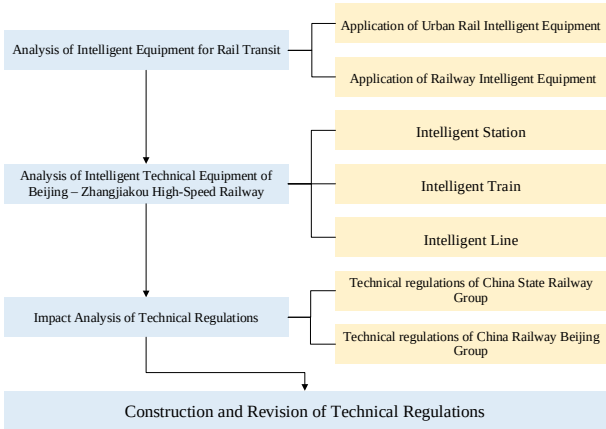

Figure 1. Construction process of technical regulation system of intelligent Beijing-Zhangjiakou high-speed railway

2. APPLICATION OF RAIL TRANSPORTATION

As shown in Figure 2, the rail transportation mainly includes urban rail and railway, which have great differences in operation process and management mode.

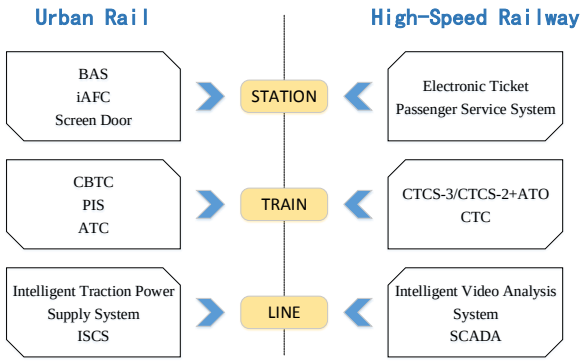

Figure 2. Application of urban rail and high-speed railway intelligent equipment

2.1. Application of Urban Rail

Smart station system is the main construction direction of urban rail station. Through the centralized display, analysis and processing of all production and service information on the site, the comprehensive management ability of stations is improved. CBTC (Communication Based Train Control System) train control system is mainly used in urban rail trains. At present, the newly-built subway lines are basically equipped with automatic driverless technology. Through wireless communication technology, trains can run in the moving block mode [1]. Screen door system has been applied in the field of rail transit for a long time. It has been used in Guangzhou Metro in 2002 and has become a standard configuration. But at the same time, screen door also brings new security problems [2]. The development direction of urban rail traction power supply system is intelligent system based on four quadrant converter technology. It can analyse a large number of operating data to achieve energy flow path planning, intelligent fault diagnosis and life prediction [3].

2.2. Application of High-Speed Railway

The existing high-speed railway mainly adopts CTCS-3 (Chinese Train Control System) train control system, which is based on CTCS-2 system and uses GSM-R (Global System for Mobile Communications – Railway) network for train-ground bidirectional information transmission. It can be applied to trains running at speeds of 300 km and above [4]. Shield doors are rarely used in the railway field. It is only set in a few lines or stations, such as Guangzhou-Hong Kong high-speed railway and Beijing-Xiong'an intercity railway. Most of them are manually controlled and cannot be combined with ATO (Automatic Train Operation) system. Similar to urban rail, the development direction of high-speed railway traction power supply system is also intelligent. It can realize intelligent maintenance, integrated early warning and auxiliary scheduling decision, through remote monitoring, measurement and control of facilities and equipment [5].

2.3. Differences

Compared with high-speed rail, urban rail is more mature in the application of intelligent equipment. Smart stations, train automatic driving system, automatic screen door and other technologies are the development direction of high-speed rail. With the opening of Beijing- Zhangjiakou high-speed rail, some technologies have been applied in the railway. The operation status of urban rail can be used as a reference in the adaptability analysis of technical regulations.

3. APPLICATION OF BEIJING-ZHANGJIAKOU HIGH-SPEED RAILWAY

As shown in Figure 3, the intelligent equipment used in the construction and operation of Beijing-Zhangjiakou high-speed railway can be mainly divided into four aspects: intelligent station, intelligent train, intelligent line and intelligent integrated dispatching system.

3.1. Intelligent Station

3.1.1. Smart Station Brain

The smart station brain is an integrated information platform constructed by using big data, artificial intelligence and other technologies for the difficulty of sharing station data and the separation of personnel and equipment. It can collect station data and collaboratively manage personnel, equipment and operation process through data analysis. This can ensure the efficient operation of the station.

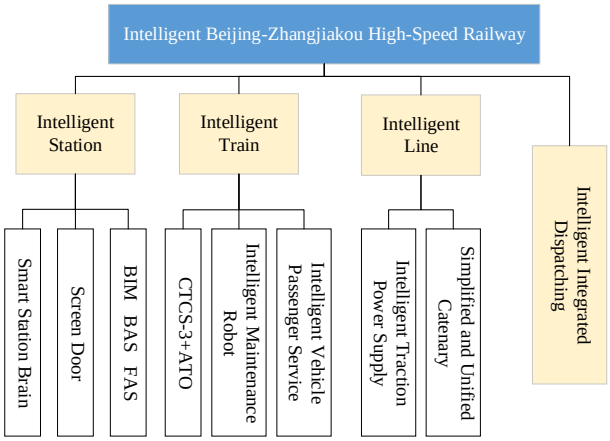

Figure 3. Composition of intelligent equipment for Beijing-Zhangjiakou high-speed railway

3.1.2. Screen Door

The screen door is set at the edge of the platform, which separates the passenger waiting area and the train operation area. It can realize automatic control through signal linkage with the train. At the same time, the screen door system of Beijing- Zhangjiakou high-speed railway adopts new materials, which can reduce the cost by 10 – 15 % compared with the existing system.

3.2. Intelligent Train

3.2.1. Intelligent Train Control System

The ATO system of Beijing-Zhangjiakou high-speed railway is based on CTCS-3. It uses on-board ATO unit, ground transponder and GPRS network to achieve precise positioning and automatic driving of trains. Compared with the previous train control system, CTCS-3 + ATO can realize the automatic operation of the train, the automatic control of the train door and the screen door, and the automatic adjustment of the operation plan.

3.2.2. Intelligent Maintenance Robot

The intelligent maintenance robot is developed by combining machine vision, artificial intelligence, image recognition and other technologies. It is mainly used for the first-level maintenance of EMUs (Electric Multiple Units). Through the manipulator and laser image acquisition module, it can automatically collect the three-dimensional image information of the detection position.

3.3. Intelligent Line

3.3.1. Intelligent Traction Power Supply System

The intelligent traction power supply system is composed of power supply facilities, dispatching system, operation and maintenance management system and communication network. Its core is to collect and analyse all kinds of data of the system, and realize fault prediction, safety assessment and safety guarantee of the system. By setting communication channels between power supply dispatching system and CTC (Centralized Traffic Control System) system, the coordination between intelligent power supply dispatching and train operation dispatching can be realized. A large dispatching mode integrating power supply and operation can be formed.

3.3.2. Simplified and Unified Catenary

In the past, the design of China's railway catenary was learned from Japan, France, Germany and other countries. The diversification of technology has brought certain difficulties to construction, operation and maintenance. Therefore, the composition, performance, material and manufacturing process of catenary equipment need to be unified.

3.4. Intelligent Integrated Dispatching System

The intelligent integrated dispatching system is composed of the integrated dispatching system and the integrated transportation planning collaborative management platform. The dispatching system can share information and exchange information with the passenger ticket system, the train diagram making system, the power supply system and the construction system through the management platform. It can realize the unified and coordinated management of operations, and its main functions include basic data management, information collection management, transportation monitoring and evaluation, dispatching management and train operation management.

4. IMPACT ANALYSIS OF TECHNICAL REGULATIONS

The impact of intelligent technical equipment on the operation of high-speed railway can be divided into two types: operation management and safety. The operation management can be divided into three aspects: train and passenger operation, passenger service, equipment application and maintenance. Different equipment has different degrees of impact in different aspects. Combined with the analysis of the functional characteristics of equipment in Section 3, this chapter will study the impact of various equipment on operation. On this basis, the adaptability of new equipment to existing technical regulations is discussed.

4.1. Intelligent Station

Due to the application of intelligent station brain system, staff can receive commands, convey information, understand equipment failure, control switch and adjust lighting by handheld terminals. When an emergency occurs, staff can receive emergency response information immediately at the devices.

The screen door is widely used in Beijing-Zhangjiakou high-speed railway station. It can effectively prevent passengers from falling off the platform. However, staff need to confirm the safety of the screen door when passengers board and alight from trains, and also need to manually control it when the equipment is abnormal.

Table 1. Operation impact and regulation adaptability of intelligent station equipment

Equipment		Operation Management			Safety
		Passenger Operation	Passenger Service	Maintenance	
Intelligent station brain system	Operational impact	√	√	√	√
	Regulation adaptability	√	√	×	√
Screen door	Operational impact	√	—	√	√
	Regulation adaptability	×	—	×	√

Table 2. Operation impact and regulation adaptability of intelligent train equipment

Equipment		Operation Management			Safety
		Train Operation	Passenger Service	Maintenance	
CTCS3+ATO	Operational impact	√	—	√	√
	Regulation adaptability	×	—	×	×
Intelligent maintenance robot	Operational impact	—	—	√	—
	Regulation adaptability	—	—	×	—

Table 3. Operation impact and regulation adaptability of intelligent line equipment

Equipment		Operation Management			Safety
		Train Operation	Passenger Service	Maintenance	
Intelligent traction power supply system	Operational impact	√	—	√	—
	Regulation adaptability	√	—	×	—
Simplified and unified catenary	Operational impact	—	—	√	√
	Regulation adaptability	—	—	×	√

4.2. Intelligent Train

CTCS3 + ATO changes the train driving mode, improves the punctuality rate and comfort, and ensures the train to operate as planned. It can also reduce labour intensity and the possibility of driver's incorrect operation. However, there is a lack of corresponding maintenance regulations for vehicle ATO, ground transponder and other equipment.

Due to the complexity of maintenance projects, manual maintenance is not only slow, but also the problem of missing detection is common. Intelligent maintenance robots can improve the efficiency of fault detection and reduce the rate of missing detection. It can continuously improve the detection accuracy by improving the algorithm. The maintenance work is very hard, which may affect the physical and mental conditions of the staff and reduce the quality of work. Using intelligent maintenance robots can avoid this problem.

4.3. Intelligent Line

Through the unified dispatching of power supply and operation, the intelligent traction power supply system can improve the operation efficiency of the lines. According to the various monitoring data provided by the system, the fault prediction, health management and auxiliary decision-making of the power supply system can be carried out. Using the output results, a reasonable maintenance strategy can be formulated to reduce the risk of failure and minimize the scope of failure.

The Simplified and Unified Catenary improves the inconsistency in technology and design of catenary in China. It is of great significance to simplify design, facilitate construction and reduce the difficulty of operation and maintenance. It can not only reduce the costs of production and maintenance, but also improve the quality and safety of catenary.

Table 4. Operation impact and regulation adaptability of intelligent integrated dispatching system

Equipment		Operation Management			Safety
		Train Operation	Passenger Service	Maintenance	
Intelligent integrated dispatching system	Operational impact	—	—	—	—
	Regulation adaptability	√	√	√	√

4.4. Intelligent Integrated Dispatching System

The Intelligent integrated dispatching system is the core of intelligent high-speed railway operation. It can improve the efficiency of information transmission, manage the business as a whole, adjust the work plan in time and enhance the adaptability to new technologies such as cloud computing and big data. It can also realize the visualization of comprehensive maintenance and timely convey to passengers information including weather, accidents and equipment failures. Using speech recognition, video analysis and other technologies, the system can monitor the operation of personnel and timely correct illegal operations. It can monitor and find the hidden dangers in the railway operation environment, and automatically alarm when dangerous situations are identified.

5. CONCLUSION

With the Beijing-Zhangjiakou high-speed railway put into operation, more and more intelligent lines will be in operation in China in the future. Due to the use of new equipment, the past operation organization may not be suitable for new lines. The revision of existing high-speed railway technical regulations has become an urgent task. In this paper, the application of intelligent equipment in the field of rail transit is analysed, and the differences between urban rail and high-speed railway are compared. The urban rail has begun to use intelligent equipment such as automatic driving system and screen doors many years ago. Therefore, when formulating high-speed railway technical regulations, the operation experience and relevant regulations of urban rail can be referred to.

The new intelligent equipment used in Beijing-Zhangjiakou high-speed railway can be divided into four categories: intelligent station, intelligent train, intelligent line and intelligent integrated dispatching system. And in this paper, the impact of equipment on high-speed railway operation is divided into four aspects: train and passenger operation, passenger service, equipment maintenance and safety. Through the analysis of the functional characteristics of intelligent equipment, it can be found that the equipment has different impacts on the operation in different aspects. For the less influential aspects, the previous regulations can be continued. However, some equipment, such as CTCS3 + ATO train control system, will greatly change the operation process, and its related technical regulations must be revised. This paper summarizes the impact of intelligent equipment on different aspects of the operation process of Beijing-Zhangjiakou high-speed railway and its adaptability to relevant technical regulations. The results can be used as a reference in subsequent regulatory revisions.

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