Study on Application Scheme of Centralized Traffic Control System to Conventional Railway

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Abstract: This paper reviews the development history of the centralized traffic control (CTC) system, sorts out and summarizes the overall application of the CTC system in China, focusing on the current application status of the CTC system to conventional railways in China. It introduces the concept of the central station and regional centralized control station based on the existing CTC system and puts forward a scheme of centralized control at the central station, in view of the current shortcomings and following the principle of "alleviating work intensity of the dispatchers and centralizing station work"; meanwhile, suggestions are raised for the development trend of the CTC system.

Keywords: centralized traffic control system; conventional railway; central station; regional centralized control station; CTC

CTC in China has gone through rapid development over the past two decades. Automatic route arrangement, safety card control, plan and command management, wireless route forecast, temporary speed limit and other functions have been put into place. It has achieved full coverage in high-speed railway and it is also being put into application in the conventional railway, which can make railway transportation safer and more efficient. However, with the improvement of China's railway network and increased demand in transportation, some problems in the application of CTC, especially in conventional railway, are gradually being exposed. It is mentioned in reference[1] that subsystems of CTC system are not coordinated and planning for the transportation organization is not perfect; in reference[2], the existing CTC system function is regionally separate, and the system deployment lacks flexibility; in reference[3], against the backdrop of growth of passenger and freight transportation, the centralized command capability of transportation dispatching is weakening. The references mentioned above point out problems of CTC system adaptability in terms of transportation organization mode, management mode and technology. Wide application of CTC in conventional railway represents the

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trend of the development of railway. In order to improve the feasibility of CTC application in conventional railway, this paper analyzes its characteristics and the application status of CTC system, and puts forward the application scheme of CTC in conventional railway.

1 History of CTC

The CTC system originated from the United States. It was first applied in New York Central Railway in 1927 and named CTC system. Centralized control of the CTC system can effectively reduce the number of field transportation personnel, and is widely employed in Europe, America and Japan. China carried out R&D on CTC in the 1960s, which can be called CTC 1.0 system. However, due to the constraints of communication technology and frequent collection and release rights of train shunting, CTC 1.0 system was not successfully applied in China.

In 2003, after analyzing the special circumstances of China's railway, the former Ministry of Railways developed a decentralized autonomous CTC system adapting to China's national conditions. In 2004, the *Technical Conditions of Decentralized Autonomous CTC System (provisional Revision)* (Science and technology correspondence [2004] No. 15) was issued, which can be called CTC 2.0 system. The system has been put into operation on Xining-Harge railway. The remarkable feature of the decentralized and autonomous CTC system is that three innovative operation modes, namely central operation, station shunting and station operation, are proposed according to different station operation characteristics. Under the three operation modes, access to train routes and shunting routes can be allocated between the central dispatcher and the station attendant in a more scientific way according to the operation situation of the station, and dynamic switching can also be carried out. The three operation modes can solve the problem of frequent collection and release of train shunting rights in CTC 1.0 system, thus realizing the cooperation between the central dispatcher and the station attendant. In addition, based on CTC 2.0 system, a series of security control measures have been taken, such as no entering in section closed up, protection of cleared section with shunting fault, protection of electric traction engine in blackout section without network, protection of out-of-gauge train track and protection of train stopping in the platform.

With the development of technology, based on application of CTC system in conventional railways and high-speed railways, in 2016, the former Ministry of Railways launched the Q/CR 518-2016 *Technical Conditions for CTC System* in 2016, which specified the new functions and interfaces in high-speed railway in detail, and also included the integrated control of train and shunting of conventional railway, improving the safety and applicability of CTC system. The system applying the upgraded technical standard is called CTC 3.0 system. In 2019, on the basis of CTC 3.0 system, the scheme "central station + regional centralized control station" (referred to as central station centralized control) was proposed, which further reduced the workload of dispatchers and improved the centralized handling capacity of station operation.

According to the characteristics of traffic control command, the CTC system integrates the work of dispatchers accordingly while at the same time train dispatchers and assistant dispatchers are arranged. The train dispatcher is mainly responsible for the adjustment of train diagram, the timely release of train adjustment plan, and the rational use of train arrival and departure tracks while the assistant dispatcher is in charge of monitoring train operation, the direct control of signals under abnormal conditions, and issuing traffic control orders. With CTC system, the work division and personnel allocation of traffic control and vehicle maintenance have changed [4].

2 Analysis on CTC Application to Conventional Railway

By the end of 2019, the mileage of railway equipped with the CTC system has reached 61,000 km. In addition to the full coverage of high-speed railways, it has reached 26,000 km of conventional railway, including 32.7% in central operation mode, 27.4% in station shunting mode and 39.9% in station operation mode. However, compared with the high-speed railway, the CTC system applied in conventional railway is far from ideal. The main reasons are as follows:

(1) Due to the transportation organization mode of conventional railway, there are many kinds of trains and station operations and, in particular, the frequent shunting operation, the uncertain operation time of freight trains, and the uncertain skylight time result in more temporary adjustment of the plan, which, to some degree, affect the performance of CTC system in terms of the diagram and the normal function of the system [5-6]. Dispatchers also need to take into account work orders while organizing train operation. Therefore, the workload of dispatchers is relatively heavy in the case of unreasonable division of dispatching console and lack of dispatchers [7]. Consequently, CTC dispatchers of conventional railways are often under huge pressure with a high working intensity.

(2) At present, most of the CTC systems in application fall into CTC 2.0. The CTC 2.0 system is able to handle all train route automatically in the control section. Manual intervention can only be carried out when necessary, such as the selection of self-triggering time and adjustment of track operation at large stations, manual handling under abnormal conditions and etc., which significantly facilitates the efficiency of train route handling. However, the CTC 2.0 system is relatively weak in shunting. As CTC 2.0 has not been connected to the train system, lack of accuracy and a plan for automatic shunting lead to impracticality in terms of automatic

triggering of shunting route. However, the changeable practical situation requires flexible measures as problem occur. For passenger and freight stations with frequent shunting operations, in practice, the majority of technical stations adopt the station operation or station shunting mode of CTC system, and even operators prefer traditional button pressing method to handle shunting route, resulting in a failure to centralize and integrate operation of CTC system [8].

(3) To achieve better application of automatic triggering of interlocking equipment and joint control of train and machine, it is necessary to adopt computer interlocking equipment in the station and to implement GSM-R network coverage and other related supporting equipment along the route. At present, the coverage rate of computer interlocking for the conventional railway stands at about 50%, and the coverage rate of the GSM-R network is about 30%, constraining the better promotion and application of CTC system [9-10].

3 CTC 3.0 and Centralized Control Scheme of Central Stations

In recent years, because of the complexity of conventional railway transportation organization, as well as some special application requirements of large hubs and technical operation stations, further R&D has been carried out based on the CTC 2.0 system to improve the application of CTC, creating the CTC 3.0 system scheme and a scheme of centralized control at the central station.

3.1 CTC 3.0 system

In view of the inadaptability of CTC 2.0 system in conventional railway, the CTC 3.0 system is improved in the following three aspects: Firstly, the plan of CTC 2.0 system, which was directly sent to the autonomous controlling machine by dispatchers, is now sent to the dispatcher and then to the station attendant and finally to the autonomous controlling machine. By doing so, the station attendant is given more power to refine the dispatcher plan, so as to make it easier for dispatchers in one station with multiple hubs to control the track and select lines between stations; Second, the automatic control of shunting route is achieved. The combination with the current train system makes the source of shunting operation plan more clear. The shunting route management realizes the functions of automatic single locking of no signal switchback turnout, automatic single locking of switches in poor shunting section, automatic tracking of shunting number, etc., achieving the integrated control of train shunting route; Third, the CTC 3.0 system has incorporated operation procedures including anti-rolling measures, water supply, pollution absorption, boarding and landing, train inspection, cargo inspection and etc., which further improves the safety of the technical station.

3.2 Centralized control scheme of CTC central station

Guided by the principle of "alleviating work intensity of the dispatchers and centralizing station work" and based on the current CTC system, the scheme of "center station + regional centralized control station" has been adopted, namely, the central control of station attendant and signal operator (see Fig. 1). Only two types of operation of CTC have been retained: station operation and station shunting, and jobs such as dispatcher's track operation, signal execution and supervision are delegated to the duty officer of central station, and the handling of train and shunting route of several centralized control stations around the central station are centralized in the central station. The central station is equipped with a centralized control station to provide a standard plan for management, track application, signal execution and supervision interface for station attendant. The scheme can reduce work intensity of dispatchers in the conventional railway while the plan of multi-station centralization can effectively solve the problem of insufficient workload of station staff with lower traffic and less shunting operation. It also reduces unnecessary on-site gatherings

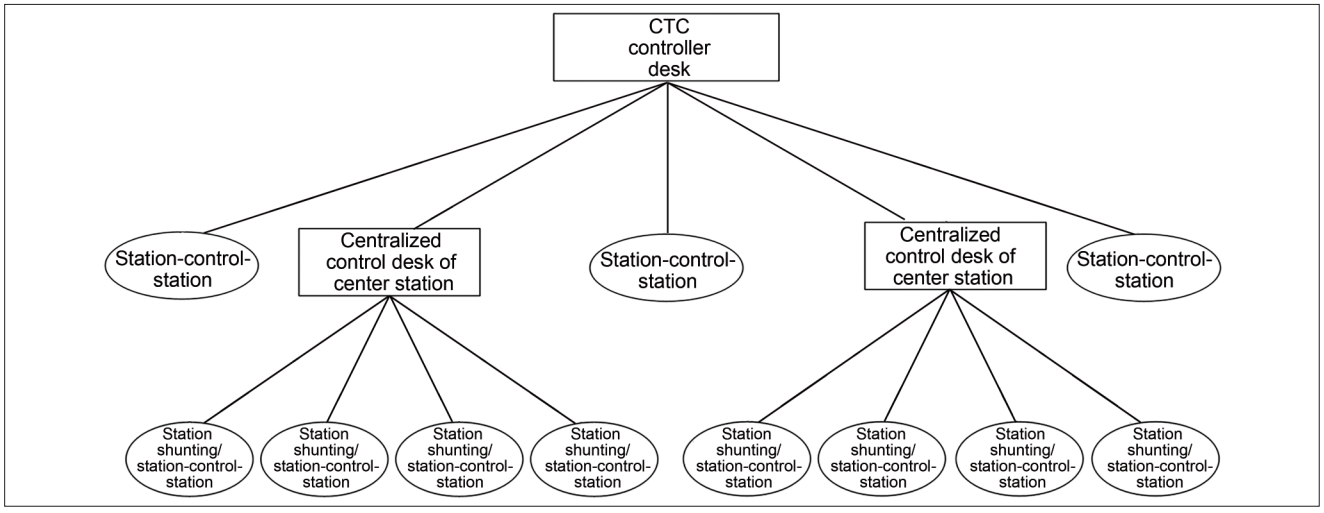

Fig.1 Centralized control scheme of center station

and makes life more convenient for the station staff, which is in line with the development trend.

The wide application of two schemes of CTC 3.0 system and central station centralized control in conventional railway will give full play to CTC and optimize setting of train operation posts. The application scheme can be selected according to the specific conditions of the line. For example, the operation mode of CTC 3.0 center can be adopted on the lines with less interference in freight lines, shunting operation and receiving-dispatching train operation. The train dispatcher can select a train/shunting route according to plan through CTC center; on the lines where shunting and receiving-departing trains frequently cross each other, the central station centralized control scheme is adopted to change the centralized dispatching control mode to the central station centralized control one, and the station equipped with special shunting locomotive is preferentially selected as the central station.

4 Suggestions and Prospects

This paper summarizes the application status of CTC system and puts forward some suggestions for the future development of CTC system based on the current information and intelligent development trend.

(1) To further promote the application of CTC system in conventional railway and achieve the integrated control of train shunting in technical station through a combination of the current train system with the aim of improving the adaptability of CTC system.

(2) To establish a multi-post interconnected system with the CTC system at its core. The station wired/wireless local area network and other transmission media are used to realize the sharing and linkage of train operation information among the station attendant, assistant station attendant, passenger transport, train inspection, freight inspection and other posts whilst still achieving the required information security isolation.

(3) To establish a big data analysis system for traffic with CTC system at its core. By leveraging the CTC system and the accumulated data of relevant system operation, the operation of dispatchers and duty personnel will be analyzed, so as to better achieve safety control. At the same time, the relevant records and data in driving can also be analyzed to master objective laws, such as throat occupation time, conflict time, etc., and to provide scientific evidence for decision-making.

In the future, the CTC system will become more automatic and intelligent by relying on information and communication technologies such as AI, big data analysis, 5G communication and BeiDou navigation system. Based on the development of signaling systems such as moving block and train control and interlocking integration system, the CTC system will play a bigger role in ensuring railway running safety and improving labor efficiency [11].

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