Current Situation and Development of Comprehensive Automation Technology in Marshalling Station

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Abstract. This paper introduces the status quo of railway marshaling stations and the main signaling equipment independently innovated in China. And then analyzes the control of hump pushing locomotive, hump access control and hump rolling speed control of TBZK II type hump automation control system. Describes the technical equipment of comprehensive automation system and its future development prospects of the new-generation marshaling stations in the end.

1. Overview of marshaling stations in China
Mostly located at the intersection of railway networks, marshaling stations are the core of railway hub and the base of freight train distribution and train uncoupling. It mainly undertakes the arrival, uncoupling, marshaling, departure of numerous freight trains and the operations of other trains. Additionally, dedicated hump classification equipment is provided for its operation. It is often called the “factory of trains”. Statistics show that during one complete turn-round time of freight trains, the operation time and stabling time account for about 70%[1].

The efficiency of the railway marshaling stations directly affects the overall level of railway freight transport, and is one of the core procedures of the entire railway industry of China. In recent years, the layout of domestic marshaling stations is greatly adjusted. There are 40 major marshaling stations with different sizes across the country, including 12 railway network marshaling stations, 14 regional marshaling stations, and 14 local marshaling stations[2].

As the “Belt and Road Initiative” is thoroughly implemented, Xinfeng Town has developed into the largest railway network marshaling station of Asia, and is the paramount station on the “Silk Road” railway. The trains of China Railway Express departing from Yiwu, Suzhou, Wuhan and Chongqing will be checked for their shipment at Xinfeng Marshaling Station and leave China via Alataw Pass or Horgos Port. Currently, Xinfeng Marshaling Station has marshaled and opened more than 8000 railways on China Railway Express to Europe and to Asia. According to the data of China Railway, Xinfeng Marshaling Station undertakes 28,101 trains per day on average in 2018, and undertook 33,112 trains on November 24, 2018, hitting a record high of daily train undertaking across the country.

Table 1 shows the vehicles handled of some marshalling stations in 2018.
Table 1. Daily average number of vehicles handled in some marshalling stations and the disintegration of humps.

| Marshalling Station Name | Type of Marshalling Station | Average number of trains per day | Highest number of trains per day | Single hump disintegration per day | Single hump highest disintegration per day |
|--------------------------|-----------------------------|---------------------------------|----------------------------------|-----------------------------------|------------------------------------------|
| XinFeng Town Station     | Network                     | 28101                           | 33112                            | 79                                | 103                                      |
| FengTai West Station     | Network                     | 22224                           | 26273                            | 85                                | 96                                       |
| Harbin South Station     | Network                     | 14174                           | 18561                            | 69                                | 79                                       |
| LiuZhou South Station    | Regional                    | 14234                           | 16684                            | 52                                | 64                                       |

2. Basic equipment

2.1. Speed regulation equipment
In China, large and medium-sized hump speed regulation equipment basically uses clamp floating rail gravity retarder as spaced braking retarder and target braking retarder. The main function of brake retarder is to adjust the connecting speed and ensure the safe connection of the slip train set, and its inlet speed is related to the number and length of the retarder installed. Compared with non-gravity train retarder, the braking force of gravity train retarder with clamp floating rail is not provided by the external force, while directly proportional to the weight of the vehicle itself, that is, the heavier the vehicle is, the larger the braking force is[3].

2.2. Measuring equipment
The main measuring equipment of hump automatic control system are speed radar, weight measuring equipment for slip-off train, idle length measuring equipment for shunting line and wheel sensor, etc.

2.2.1. Speed Radar. In order to realize the automatic control of the retarder, the hump automatic control system must continuously measure the real-time movement speed and speed change of the sliding car group in the retarder section. 8mm wave Doppler radar is widely used to measure the real-time velocity of slip-off vehicle group in hump velocity control in China. It has the advantages of high speed measurement accuracy, instantaneous velocity continuous measurement, small power frequency interference, convenient maintenance and so on.

2.2.2. Weight Measuring Device. The weight measuring device is used to measure the axle load of the automobile group, which is an important basis for the hump automatic control system to determine the braking grade of the retarder and evaluate the slip characteristics of the whole train set. The weighing device is mainly composed of outdoor weighing sensor and indoor weighing signal processing equipment. Most humps in our country use plug nails to measure the weight, while the plug hole piezomagnetism sensors installed directly on the slide rail are used as weighing sensors. The shear force produced by the weight load of the wheel is measured by using the piezomagnetism effect, and the output is proportional to the weight of the wheel.

2.2.3. Length Measuring Equipment. The idle length of shunting line is one of the important bases for calculating the exit speed of retarder by hump control system, which is obtained by real-time measurement of length measuring equipment. When the rolling train set occupies or walks on the track of the measuring section, the distance from the last wheel shaft of the train group to the starting end of the track changes, and the short circuit input impedance of the track circuit also changes accordingly. Based on the change of signal collected by computer length measuring device, the measurement data
are processed by artificial intelligence through reasonable mathematical calculation model and software, and the idle length of shunting line is calculated.

2.2.4 Wheel Sensor. The hump wheel sensor is a device that detects the wheel passage. It is used in the hump control system to measure the shaft and speed of the rolling train set. Based on the principle of electromagnetic induction, the wheel signal is generated by the change of magnetic flux of the sensor when the wheel passes by. Because of its simple structure and reliable operation, it has been widely used.

2.3 Hump switching equipment

Hump switch can be divided into ZD7 type electric switch machine and ZK series electropneumatic switch machine according to the power used. In order to meet the requirements of hump slip work, the action time of electric switch is not more than 0.8s, and the operating time of electric switch is not more than 0.6s.

3 Computer automatic control system of hump

The hump automatic control system in China divides the hump shunting operation process control into three parts by function, that is, hump pushing locomotive control, hump route control and automatic rolling down speed control. Each part is completed by a separate computer, and the computer local area network forms a decentralized control and centralized management control system[4]. Fig. 1. shows TBZK II Automatic Hump Control System that it is widely used in China.

3.1 Hump pushing locomotive control

By collecting the open circuit conditions of the hump signal and the interlocking condition of the arrival yard, the hump push speed wireless remote control system sends peak control commands and signals from the ground equipment to the locomotive and rolling stock equipment. According to the peak pushing control instruction, the vehicle equipment controls the peak pushing speed of the peak pushing locomotive, and realizes the variable speed push peak operation of the disintegrating train.

With regards to the remote control command, the on-board equipment controls the automatic start, speed adjustment, forward, backward, parking, braking and automatic whistle of the push peak locomotive and a series of functions.

![Figure 1. Structural of TBZK II Automatic Hump Control System](image-url)
3.2. Hump route control
Hump route control includes push route control, slip route control and shunting route control. The switch action and signal display are controlled by the control computer through the execution relay or circuit of the switch and the signal machine, and the presentation information is received.

The hump push route control completes the route control between the arrival yard and the peak hump signal, and ensures the locking of the through route and the opening of all kinds of signals in the train disintegration operation. According to the disintegration plan, the hump slip speed is controlled and the sliding control of each train set is completed.

In order to improve the disintegration ability, it is required that as soon as the forward train set leaves the bifurcation section, it is necessary to change the switch in time and prepare the way for the next train set. For this reason, the slip approach of each train set adopts the control mode of establishing step by step, using it step by step, and unlocking step by step.

3.3. Automatic rolling down speed control
The spaced braking position retarder is controlled in the hump fork area to maintain a certain interval between the front and rear trains, and to ensure that the shunt switch can be converted in time based on the requirements, which is called spaced speed regulation. After the train enters the shunting line, the target braking position retarder is controlled so that the train is connected to the parked train set at a safe connecting speed, or stops in a predetermined position, which is called target speed regulation.

When the slip train set enters the retarder section, by measuring the speed through the radar, the actual speed of the slip car group is compared with the calculated speed, and according to the comparison results, the brake or relief of the retarder is controlled or relieved so that the train set leaves the retarder at a speed close to the calculated speed.

4. Integrated automation system of marshalling station
The integrated automation system of marshalling station is the core achievement of the comprehensive innovation of technical equipment and operation concept of marshalling station in our country[5], and it is the key technology of reducing staff, increasing efficiency and ensuring safety of railway freight transportation in our country[6].

Through the establishment of a centralized control information platform to integrate management and control, the management level and the control level are separated and then connected by the safe interface. The management level automatically issues a plan to the control level, then the control level breaks the command down as per the plan, automatically controls the operation equipment on site and feeds actual operation results back to the management level, which adjusts the operation plan in real time based on the feedback, forming a closed-loop management and control of whole-operation process[7]. The schematic diagram of the system structure is shown in Fig. 2.
5. Development of automation technology in marshalling station

The application practice of modern equipment in marshalling station shows that: the advanced control technology and information technology greatly improve the comprehensive ability of marshalling station, greatly reduce the accident rate of shunting, improve the economic benefit index, provide strong technical support, and provides equipment support for reducing the number of operators and increasing the amount of work at the station[8].

The automation technology of marshalling station greatly improves the working conditions of workers, reduces the labor intensity of workers, improves the labor efficiency, and greatly improves the safety level of personnel and vehicles[9].

In the aspect of hump control technology, in accordance with the number and combination of different axle load trucks, the technical scheme of how to ensure the control accuracy and safe connection of the existing hump field slip train set is further studied.

In the aspects of comprehensive automation technology of marshalling station, with the latest information theory and technology, reference and utilization of the research results of artificial intelligence[10], and make a profound study of the comprehensive guarantee technology of operational safety, the optimization control method of operation process, the comprehensive integration and utilization of information so as to push the technical level of the signal equipment of the marshalling station to the information, the intelligent and the automatic in-depth development.

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