Identification and Resolution of Operation Capacity Bottleneck of Technical Station

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Abstract—In order to improve the operation efficiency of technical station, it is necessary to study the identification method and resolution strategy of the operation capacity bottleneck of technical station. Based on relevant research, this paper analyzed the utilization of the operation capacity of the technical station, considered the service capacity and level of the equipment inside the station, established the capacity bottleneck identification model, and put forward the methods and steps of capacity identification. Besides, aiming at the bottleneck of technical station's ability to handle the transfer and reclassifying operation, raised the corresponding solving strategy. With a lower investment, through the use of optimized transportation organization technology and the efficient use of technical equipment, to improve the capacity of bottleneck and compress the detention time of railcars in the technical station. Therefore, accelerated the turnover of locomotive and rolling stock, and improved the reliability and service quality of the whole road network.

Keywords-technical station; transfer and reclassifying operation; identification of capacity bottleneck; resolution of capability bottleneck

1 INTRODUCTION

Many scholars have studied the identification and resolution of capacity bottlenecks, and have obtained rich results. The capacity and bottleneck of technical station were represented and estimated by three-parameter interval grey number [1]. A static identification model of station bottleneck was proposed to analyze the bottleneck problem [2]. A method of passenger flow bottleneck screening based on reverse search was proposed [3]. The capacity bottleneck identification model and service bottleneck identification model based on passenger flow prediction model were proposed [4]. At the same time, through the analysis of various indicators, the measures to eliminate the bottleneck of railway capacity were systematically studied [5]. A bottleneck identification model based on a pedestrian mustering and evacuation network was established from the perspective of internal and external passenger flow distribution in the network system [6]. To improve the turnover efficiency of cars and increase transportation benefits, it is necessary to analyze the actual capacity utilization of each equipment and link in the technical station and find out its weak link, which means the "bottleneck" of the transfer and reclassifying operation ability of the technical station. And it is necessary to put forward the corresponding resolution strategy. Only in this way can we make the system's ability of the whole

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technical station get promoted. In the actual transportation organization work, since the railcar reclassifying operation is influenced by many factors, detention time of railcar in transferring and reclassify is made up by many time periods, and to ensure the safe operation of railcars, there are some operation items have a certain time in the process of railcar reclassifying at the technical station. This part is immutable, such as various technical inspection time of the train, the technical inspection and repair of vehicles, and the other part of the reclassifying operation time is variable, especially the arrival, disintegration, accumulation, marshalling and departure process of transfer car with resorting, i.e. marshalling station work organization. Therefore, the operation capacity bottleneck of a technical station is generally determined by the capacity level, service capacity of the relevant operation equipment of the technical station. It is also determined by the coordination of each operation process and the organization of train operation mode of the technical station.

2 OPERATION CAPACITY BOTTLENECKS OF TECHNICAL STATION

2.1 Overview of Capability Bottleneck Identification

At present, there are many researches on capacity bottleneck in China. The definition of bottleneck varies with different research objects, and there are also different identification methods [7-10], as shown in Table 1.

Based on the urban rail transit, subway and general railway capacity bottleneck, we define the railcar transferring and reclassifying operation capacity bottleneck in the technical station as the facilities and equipment beyond their maximum available capacity in the process of the railcar transferring and reclassifying operation in the technical station.

Table1 Capacity Bottleneck Research Status

Capacity bottlenecks	Definitions
Transport capacity bottleneck of urban rail transit system	Under the condition of none passenger flow, the station or line of the urban rail transit system with the smallest transport resource allocation or full load operation.
Evacuation capacity bottleneck of urban rail transit station	Under the condition of emergency evacuation of urban rail transit, the station facilities with overloaded inflow passenger flow or excessive passenger flow density and too low passenger flow speed.
Bottlenecks in urban rail transit station	In urban rail transit stations, the passenger flow exceeds the transport organization load or capacity, resulting in excessive passenger flow density and low speed of passenger flow which go through the station equipment and facilities.
Passenger flow bottlenecks of urban rail transit station	Under the condition of emergency evacuation of urban rail transit station, passenger flow is the slowest part in evacuation process.
Bottlenecks in urban rail transit network	Key stations or lines that have decisive influence on the transport efficiency and service level of urban rail transit network.
Capacity bottleneck railway transport production	Facilities and equipment that exceed their maximum available capacity.

Meanwhile, the railway bottleneck is subdivided into static bottleneck and dynamic bottleneck. Static bottleneck is due to the lack of consideration of the connection and matching between the equipment in the planning and design of each technical station, such as the number and location of various equipment. Dynamic bottleneck refers to the freight traffic flow congestion phenomenon caused by the high concentration of trains in some areas of technical stations, which exceeds the operation capacity of daily facilities and equipment. It is causing by the insufficient estimation of freight flow, insufficient understanding of freight flow characteristics and imperfect transportation organization scheme of technical stations.

2.2 Construction of Railway Capacity Bottleneck Identification Model

Dynamic capacity bottleneck has relations with many factors. Arrange the operation process reasonably in station and reclassify the related equipment, and consider the service ability and level of every device inside the station. After determining the number of trains arriving and departing from the station, we can calculate and determine dynamic capacity bottlenecks, the capacity bottleneck identification model is as follows:

$$B_{k,m}^{N} = \{b_{k,m,n}^{N} \mid Q_{d,k,m,n} > \theta_{k,m,n} \times F_{k,m,n}, d = 1,2,3\cdots, x\} \tag{1}$$

In Formula (1), d is different stages in the planning cycle (short , middle and long terms); $B_{k,m}^{N}$ is the set of dynamic capability bottleneck facilities in station m of line k; $b_{k,m,n}^{N}$ is the dynamic capability bottleneck facility in station m of line k; $Q_{d,k,m,n}$ is the number of trains to be reclassified or connected by facility n in line k in station m of stage d; $\theta_{k,m,n}$ is the maximum utilization rate of the receiving and dispatching capacity or the reclassifying capacity of facility n in station m of line k; $F_{k,m,n}$ is the carrying capacity or reclassifying capacity of facility n on line k in station m; x is the total number of stages in the planning cycle.

2.3 Capability Identification Methods and Steps

STEP1: Determine related calculation parameters. Various parameters will be applied in the calculation process, and the number is large. Its definition and value need to be determined scientifically and reasonably to ensure the accuracy of the calculation process. The parameter determination method needs to be scientifically formulated after access to relevant information, so the parameters will be more accurate. Thus, lay a good foundation for the subsequent calculation.

STEP2: Calculate the carrying capability and reclassifying capability. Get the data in the actual production process of the station, calculate the changes in the utilization rate of arrival and departure lines, switches and other related facilities in the station, make statistics of the car flow, determine its distribution in the station.

STEP3: Identify capability bottlenecks. Based on the analysis of carrying and reclassifying capacity utilization of equipment in the station, whether the dynamic capacity bottleneck is existed in the station is judged.

3 THE SOLUTION STRATEGY FOR THE BOTTLENECK OF FREIGHT CAR REARRANGEMENT AND TRANSFER CAPACITY OF TECHNICAL STATION

In view of the bottleneck of the technical station's transfer and reclassifying operation ability, corresponding strategies should be found out to improve the technical station's transferring and reclassifying operation ability. Generally speaking, in order to solve the bottleneck of the operation capacity of the technical station, the method of optimizing the transportation organization can be used to solve the bottleneck, i.e. to improve the capacity of the bottleneck by using the optimized transportation organization technical means and efficient use of technical equipment with low investment. The main measures are as follows.

3.1 Strengthening Multi-disciplinary Coordination and Cooperation

In order to improve balance of the car flow distribution in the station, we need to strengthen each link and interaction between various devices in technical station to enhance the efficiency, reduce resource waste and unbalance and reduce the waiting time between each link. It makes the whole process appears to be more complete and quickly.

3.2 Reasonable Selection of Departure Mode

The most direct impact of different departure modes (select different minimum number of reclassify cars *m.*) on the transportation organization of marshalling station is to change the detention time and departure times of vehicles at the station, thus affecting the original cost. In addition, different departure modes also deeply influence the operation of marshalling stations, adjacent operation segment and the transport of downstream technical station. Besides, Fixed-point departure tends to improve the organizing efficiency of marshalling stations and related work, and the detention time of freight cars in the transhipment stations will be too long due to the small car flow in the direction of trains in fixed-point departure mode. In order to improve the station operation efficiency, it is necessary to formulate the train operation diagram reasonably, and arrange the train operation in the station strictly according to the plan of the train operation diagram, so as to improve the accuracy and efficiency of the station operation, and reduce the waste of resources and time. Due to the limitation of relevant transportation capacity, transportation cost and efficiency, it is impossible for fixed-point assembly trains to depart under loaded without reason in the actual transportation process. Therefore, a reasonable range of reclassify car numbers is particularly important, which needs to be determined within the permissible range of line conditions. And under loaded train will produce waste of corresponding locomotive traction power, in order to reduce the occurrence of this situation, we can choose to get the under loaded trains loaded in technical station or intermediate station during transporting. Get trains loaded in the intermediate station which contains the relevant car flow and required equipment condition has less influence than getting trains loaded in the technical stations which has relatively stable car flow. The reason is that getting the under loaded trains loaded will disrupt the normal operation process of technical stations with relatively stable car flow.

3.3 The Passing and Detention Time of Transfer Trains Without Resorting Should be Reduced to Solve the Shortage of Leading Locomotives

There are many factors that are related to the detention time of the transfer trains without resorting, such as the number of leading locomotives, the requirements of technical operation, and the operation of the train on the arrival and departure lines. Based on this, it is necessary to optimize the technical operation process and related technical equipment in the station to improve the operation efficiency of the transfer trains without resorting, and meet the needs of the leading locomotive departing from and entering into the engine shed. Any problems of the arrival of trains and the supply of local locomotives will have a significant impact on the transfer trains.

Therefore, it is necessary to arrange the traction locomotive reasonably in time to ensure that the locomotive can be supplied accurately, and match the departure lines and arrival lines of the transfer trains reasonably in the process of compiling the train diagram. So as to make the operation of the transfer trains without resorting more quickly.

3.4 Increase the Number of Passing Trains Without Resorting in the Technical Stations

Many factors, such as the capacity and condition of the relevant shunting equipment, the volume of car flow, the passing capacity of marshalling stations, etc., can influence the organization of the through trains and transit trains. Current proportion of passing trains without resorting in the technical station is not high. Although in recent years, under the national organization, the number of the through trains originated from one loading point has been significantly improved, but it still needs further development. If the proportion of passing trains without resorting in national railway technical stations is rising, the operation efficiency of the marshalling station will be greatly improved, the train passing and detention time will be greatly reduced, and the operation level of the technical station will be further improved, which is conducive to the improvement of the reclassifying operation capacity of the national technical station.

3.5 Optimize the Reclassifying Operations, Strengthen the Transportation Production Organization, and Compress the Waiting Time of Nonproduction Operations

Breakup and makeup capacity of the marshalling station is an important factor of technical efficiency, in order to improve marshalling efficiency and reduce the train passing and detention time, the technical equipment and operation organization level of marshalling station need to be optimized. While enhancing the level of production organization and reducing the necessary operation time, the time required for the nonproduction operations also need to be compressed as much as possible. In this way, the technical operation level of marshalling yard can be optimized and the influence of other factors can be reduced. The methods to compress the breakup and makeup time are as follows.

3.5.1 Reasonable distribution of reclassifying operation volume for each marshalling station

After determining the distribution of car flow in the railway network, according to the technical equipment level of marshalling stations and their role in the railway network, the work volume of marshalling stations is allocated to reduce the imbalance between different marshalling stations. So as to avoid the marshalling stations from being unable to handle the reclassifying operation, and improve the adaptation level of the whole railway network.

3.5.2 Strengthen the ability of unpacking, optimize the operation scheme, further improve the efficiency of breaking-up and sorting

Improving the efficiency of breaking-up and sorting is an important means to optimize the process of reclassifying operation. It is necessary to arrange and allocate the use of shunting locomotive reasonably, reduce nonproduction time and improve the using efficiency of shunting locomotive. In view of this situation, the operation scheme can be optimized. If the leading locomotive cannot be used, the assisting locomotive can be used to carry out relevant operations in time to ensure the integrity of the whole operation process, improve the efficiency of breakup and makeup operation, and strengthen the ability of breakup and makeup capacity.

3.6 Organization of Car Flow Optimization

Freight train marshalling plan is a key part in car flow organization operation. Technical operation of technical station should be organized strictly according to the contents of freight train marshalling plan in daily production. The station of all kinds of trains and all kinds of goods also need to be in a reasonable management of the organization and arrangement. The operation efficiency of the whole railway network should be improved while improving the operation level of the technical station. At the same time, timely and reasonable response to accidents should be carried out, and strict safety management should be carried out. Thus, make the whole car flow organization process more perfect, and improve the efficiency and level of operation.

3.7 Adopt Flexible Train Organization Way, Strengthen Transportation Organization Work, Compress Railcar Assembly Time

3.7.1 Implement freight centralization, merge train group numbers with small car flow, in order to compress the hour consumption of assembly railcars.

3.7.2 Implement flexible train organization to compress the hour consumption of assembly railcars.

Except for pick-up and drop trains and transfer trains, all trains departing from technical stations have standard requirements for weight or length. In the formula $T_j = cm$ (car hours), the number of cars m is an important factor determining the size of T_j. It is also an effective way to compress the hour consumption of assembly railcars by flexibly adjusting and increasing the number of trains or merging train group numbers with small car flow volume.

3.7.3 Strengthen the daily transportation organization, organize the car flow operation quickly to compress the hour consumption of assembly railcars.

3.8 Accelerate the Modernization of Transportation Information Processing and Improve the Level of Transportation Organization

If the modernized transportation information processing system is used, it is possible to change the current situation of passively bearing unbalanced transportation, realize the relative equilibrium transportation actively in a planned and prepared way, optimize the transportation organization plan, allocate the locomotive and vehicle reasonably, and accelerate the car flow transportation. At the same time, based on the accurate grasp of information, it can improve the

reliability of transportation production organization and command departments at all levels of planning, so that the transportation production process is in a high efficiency state.

3.9 Other Aspects

3.9.1 Pay attention to the vehicle repair capacity and demand of the whole railway.

Update the car repair equipment of the car depot, improve the car repair capacity. And solve the problem of too much vehicles under repairing and vehicles under repairing get crowded in the track of marshalling station which affects the station production order and efficiency.

3.9.2 Establish an effective assessment and incentive mechanism.

Mobilize the enthusiasm of all aspects, do a good job of cooperation, and reduce the transfer and detention time of freight cars in the technical station.

3.9.3 Improve the quality of transport enterprise workers.

Enhance the reliability and effectiveness of their work, ensure the accuracy, reliability and timely of production operations, and improve the level of the establishment of daily and shift traffic plans and daily transportation scheduling command. Provide a good guarantee for the compression of the transfer and detention time of freight cars in the technical station.

4 CONCLUSION

In this paper, the railcar transferring and reclassifying operation capacity bottleneck of marshalling station were studied, and according to the urban rail transit, the subway and general railway capacity bottlenecks, the definition of the railcar transferring and reclassifying operation capacity bottleneck was given, built the railcar transferring and reclassifying operation capacity bottleneck identification model， recognition methods and steps. This paper found out the bottleneck of the general technical station's ability to deal with the transferring and reclassifying operation, and put forward the corresponding resolving strategy from the aspect of optimizing transportation organization method. Therefore, it provides some methods and countermeasures for the compression of the detention time of the railcars in the technical station, the improvement of the turnover efficiency of the locomotive and vehicle, the improvement of the efficiency of the technical station to handle the transferring and reclassifying operation, the acceleration of the delivery of goods, and the improvement of the reliability and service quality of the whole railway network freight transportation.

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