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The empty wagons adjustment algorithm of Chinese heavy-haul railway

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ABSTRACT

The paper studied the problem of empty wagons adjustment of Chinese heavy-haul railway. Firstly, based on the existing study of the empty wagons adjustment of heavy-haul railway in the world, Chinese heavy-haul railway was analyzed, especially the mode of transportation organization and characteristics of empty wagons adjustment. Secondly, the optimization model was set up to solve the empty wagons adjustment of heavy-haul railway and the model took the minimum idling period as the function goal. Finally, through application and solution of one case, validity and practicability of model and algorithm had been proved. So, the model could offer decision support to transport enterprises on adjusting empty wagons.

1. Introduction

Because of the quick development of CRH in recent years, part of passenger traffic volume of existing railways has been transferred to the high-speed railways. So, the ability of freight transportation of existing railways gets enhanced, and optimization of transportation organization of existing railways becomes more possible. The developing direction of Chinese railway freight are logistics for high valued freight and heavy-haul transportation for mass freight at present [1].

The heavy-haul transportation can enhance the traffic ability and labor productivity, and also reduce transport cost notably. According to the analysis of BNSF, organizing the heavy-haul trains of 120 wagons loaded 112.5t, which will save 5.2% of transport cost every year, can obtain the best economic benefits. The heavy-haul railway mode is different between different countries. There are mostly unit heavy-haul trains on American heavy-haul railway and combined trains on Chinese heavy-haul railway, therefore, organization means have nothing in common with each other in transportation of heavy-haul railway.

The heavy-haul railway is a dynamic complicated system, and the adjustment of empty wagons is an important link. In order to guarantee the continuity of transport course, it is very important to organize the empty wagons sent to loading areas from unloading areas continually. The adjustment of empty wagons is a method of traffic flow adjustment to rationally distribute the serviceable wagons to meet the need of wagons loading.

As to the issue of empty wagons adjustment, the past research works mostly direct against on complexity of network structure and dynamic changes of transportation and production of railway, the purpose is to improve models in order to realize abstract description of actual adjustment and try hard to narrow the scale of the model constantly [2–10]. Special literature is still few that study empty wagons adjustment according to the characteristics of heavy-haul railway. Firstly, the foreign heavily-haul railway mainly relies on the new and high technology and equipment. The apparatus has abundant maintenance time. Transportation organization (including empty wagons adjustment) is simpler instead; Secondly, Chinese transportation system of heavy-haul railway lack of special further investigation, the related mode and method of transportation organization are not systematized, which need further investigated.

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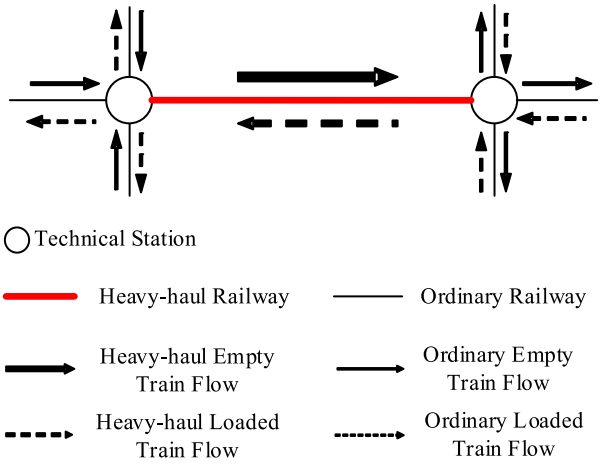

Fig. 1. Traffic flow organization of Chinese heavy-haul railway.

The issue of empty wagons adjustment differ from each other between different modes of heavy-haul railway. The issue need be studied according to the corresponding particularity. So, the paper based on the thought optimizing the issue of empty wagons adjustment, set up a model of that for Chinese heavy-haul railway.

2. Analysis of empty wagons adjustment of Chinese heavy-haul railway

2.1. Mode of Chinese heavy-haul railway

The mode of Chinese heavy-haul railway, of which both ends connecting relevant lines in the railway network, is relatively independent in the railway network. In this mode, the source and destination of traffic flow are relatively more complicated, and the majority of traffic flow need make-up or break-up of trains in technical station in either ends of railway, thus form the mode of Chinese heavy-haul railway, shown in Fig. 1.

In the empty wagons flow direction of the heavy-haul railway, on the influence of the unloading apparatus, most heavy-haul train sets (long trains) arriving at unloading stations should be disassembled to unload the freight, thus, one train set unloaded became several trains (short trains). So, in Chinese heavy-haul railway, the technical stations combining or disassembling train are called combination station or disassembly station. The train sets (long trains) combined by some trains (short trains) called combination trains, while the short train sets are called unit trains.

The main types of trains operated in the railway are combination and unit heavy-haul trains, and direction of loaded or empty trains is generally fixed. Loading and unloading stations are separately arranged in each end of heavy-haul railway. Therefore, combination stations and disassembly stations are set up separately in each end. In unloading end, unloading stations link to the combination stations (for the train with empty wagons). If the trains with empty wagons from one unloading station need to be combined, they will generally be connected corresponding to the loaded trains, shown in Fig. 2.

For example, Datong–Qinhuangdao railway is a closed ring system, but both ends of the railway connect many other lines among the railway network, thus form the heavy-haul railway system. In loading end, there are many loading stations located in Shanxi province, Shaanxi province and Inner Mongolia. When the trains are loaded by freight, mainly coal, they are transported through Datong–Qinhuangdao railway to the unloading stations in unloading end located in Hebei province and Northeast China Region. Datong–Qinhuangdao railway is a typical Chinese heavy-haul railway.

2.2. Characteristics of empty wagons adjustment of Chinese heavy-haul railway

The wagons of Chinese heavy-haul railway are attached to certain stations hence empty wagons adjustment has certain particularity. The directions of empty wagons flow, according to which empty wagons are concentrated and transported, have often been fixed. Compared to empty wagons adjustment on ordinary railway, the particularities of heavy-haul railway mainly include the following.

(1) Generally, empty wagons of heavy-haul railway are distributed in the form of a train. According to weight and wagon type, the train sets of empty wagons can be divided into several types.
(2) Because of the difference of the cycle of capital repair and interval time between trains, the transport capacity of the direction of empty wagons is more abundant than that of the direction of loaded wagons; hence, the train diagram of heavy-haul railway can be arranged as train diagram not in pairs.
(3) The empty wagons flow has basically been fixed and will not show convection.
(4) The wagons used in heavy-haul railway are expensive specialized vehicles of heavy axles, so the turnaround

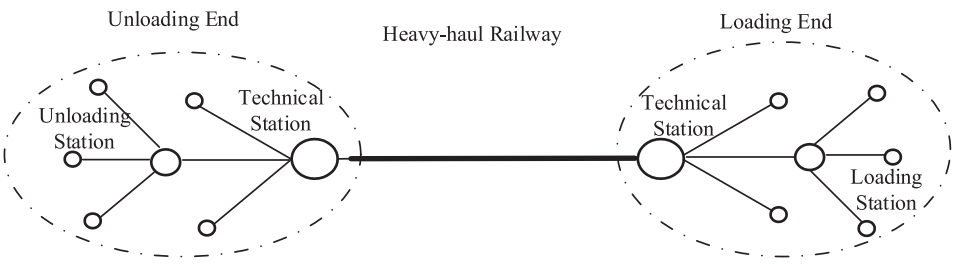

Fig. 2. Topological diagram of Chinese heavy-haul railway system.