Research on Safe Operation and Dispatch Command of High-speed Railway in Alpine Region

Changsheng Zhang1,2,* Jinsun Lee2

1 Jilin Railway Technology College, Jilin, Jilin Province, China.
2 Woosong University, Daejeon, South Korea.

How to cite this paper: Changsheng Zhang, Jinsun Lee. (2023) Research on Safe Operation and Dispatch Command of High-speed Railway in Alpine Region. Engineering Advances, 3(3), 216-220. DOI: 10.26855/ea.2023.06.012

Received: May 30, 2023
Accepted: June 28, 2023
Published: July 26, 2023

*Corresponding author: Changsheng Zhang, Jilin Railway Technology College, Jilin, Jilin Province, China; Woosong University, Daejeon, South Korea.

Abstract

With the development of railway technology, railways in alpine regions are gradually being constructed. Different from ordinary high-speed railways, alpine high-speed railways have higher construction costs, higher operation and maintenance technologies and costs, and their dispatching and commanding is also difficult. This paper will discuss the operation of the alpine high-speed railway from the perspective of the safe operation and dispatching of the alpine high-speed railway. With the improvement of people's living standards and the advancement of science and technology, alpine high-speed rail is an important form of railway transportation, and we need to conduct in-depth research on its safe operation and dispatching command. The safety operation and dispatching command system of high-speed railways in alpine regions is a high-risk system with a rather complex structure. Analyzing and managing its safe operation, dispatching and commanding can effectively enhance the management effect of railways, strengthen safety, operation and research on dispatching command can effectively promote the development of railways and better serve the people.

Keywords

Alpine region, high-speed railway, safe operation, dispatch and command

1. Relevant definitions

1.1 Alpine regions

Alpine regions generally include two situations. One situation is an area with high altitude, perennial low temperature, and permafrost that does not melt all year round; the other situation is an area with high latitude, perennial low temperature, and permafrost that does not melt all year round. My country's alpine regions include northern Heilongjiang Province, the Qinghai-Tibet Plateau, Gansu, Inner Mongolia and other parts of the country.

1.2 Alpine high-speed rail

A railway passenger dedicated line built in areas where the lowest temperature in winter is lower than -15°C, where all exposed facilities and equipment can withstand the test of a low temperature of -50°C, and the target speed of the offline (infrastructure) design reaches at least 200 km/h, And the railways and trains of high-speed EMUs with trains starting with G on this line are generally called high-cold high-speed railways [1].

1.3 Research background

1.3.1 Construction status of international alpine high-speed railway

In the 19th century, under the background of industrialization, many railway lines in alpine regions were built in western countries, but they were basically ordinary railway lines. The alpine regions of western countries are distributed in Europe, and mainly include two types. One is in mountainous areas, accompanied by heavy snow and low tempera-
ture. Railway line equipment needs to adapt to heavy snow and respond to corresponding conditions. And the other type is snow that is high in temperature and low in temperature. In terms of alpine high-speed rail, there are only three in Western countries, all of which are located in Europe. The first high-altitude high-speed railway is the Moscow-St. Petersburg high-speed railway in Russia. It was opened to traffic on December 17, 2009. The speed is generally 220 kilometers per hour. The one-way line generally takes about four hours; The second high-cold high-speed railway is the Moscow-Nizhny Fugorod high-speed railway in Russia. It was opened to traffic on July 30, 2010, and the entire line took about eight hours; The third alpine high-speed railway is the St. Petersburg-Finland Helsinki high-speed railway, which opened to traffic on December 12, 2010. It has a total length of 443 kilometers and a maximum speed of 220 kilometers per hour. It takes about three and a half hours from St. Petersburg to Helsinki. The longest of these three alpine high-speed railway lines is less than 700 kilometers.

1.3.2 Construction status of high-speed rail in China

There are many high-altitude high-speed railways in my country, and we mainly introduce typical high-altitude high-speed railways. The first high-altitude high-speed railway in China is the Harbin-Dalian high-speed railway. The line is from Harbin to Dalian. The total length of the line is 921 kilometers. It is a double-track electrified railway with a design speed of 350 km/h. It started operation in December 2012, and the train operating speed is 300 km/h. The Harbin-Dalian High-speed Railway connects Harbin City, Heilongjiang Province, and Dalian City, Liaoning Province. It is a north-south high-speed railway and one of the most important railway lines in Northeast China.

2. Characteristics and technical problems of high-speed rail in high cold

2.1 Analysis of current status of high-speed railway safety operation and dispatching command

2.1.1 The safety operation and dispatching command of high-altitude high-speed railway are complicated

The high-cold high-speed railway safety operation and dispatching command system is a very large, intricate, complex and interlocking system. At the same time, it is necessary to deal with the intricate train operation, and to face the impact of unfavorable natural conditions in the alpine region on the train operation. There are many issues that need to be considered.

2.1.2 Leap-forward development of safety operation and dispatching command of high-speed railway in high cold

Compared with foreign developed countries, China's high-speed railway has a short development history and short research and development time, and it is also the first country to start the construction and operation of high-speed railway in cold weather. Therefore, from the birth of my country's alpine expressway to the present, there has been a leapfrog development in terms of time and technology. There are still many problems to be continued, studied and discussed in terms of safe operation and dispatching command, and many technical problems still need to be solved by railway workers. At the same time, when considering solving these problems, we cannot simply analyze the problems from the perspective of ordinary railways and high-speed railways. We need to use new ideas and methods to explore and solve them.

2.1.3 Safety operation and dispatch command evaluation system of alpine high-speed railway

The safety operation and dispatch command evaluation system of alpine high-speed railway is an evaluation index system influenced by many factors. We need to start from the four perspectives of "human, machine, environment, and management", and use it as the main research object to establish an evaluation system for the safety operation, dispatching, command, and evaluation of high-speed railways in the cold and cold. At the same time, for high-cold high-speed railways, the environment will bring many unfavorable factors to the safe operation and dispatching of trains. We need to focus on the impact of environmental factors. At the same time, the connection and cooperation of various equipments will also bring many problems to the railway work.

2.2 Characteristics of Alpine High-speed Railway

2.2.1 Need to adapt to subgrade settlement [2]

The roadbed is the foundation of the railway line and an important part of the railway line. The stability of the roadbed determines whether the railway line can operate normally. When constructing alpine high-speed railways, it is necessary to fully consider the impact of subgrade settlement on railway lines caused by permafrost. The relevant technologies of the Qinghai-Tibet Railway to conquer the permafrost can be applied to the Harbin-Dalian High-speed Railway, the Lanzhou-Xinjiang High-speed Railway, the Haqi Passenger Train, the Ha-Jia Passenger Train, and the Harbin-Mu Passenger Train, which has great reference value for the construction of the northern Xinjiang passenger dedicated line.
2.2.2 Appropriate speed control

Due to the harsh operating conditions, the alpine high-speed railway is not suitable for high-speed operation, otherwise it will affect the safety of operation. Because the definition of high-speed railway clearly stipulates that newly-built passenger-dedicated railways are designed to run 250 km/h (including reserved) and above EMU trains, and the initial operating speed is not less than 200 km/h [3], at the same time, the alpine high-speed railway should not be too slow, otherwise it is not a high-speed railway. For ordinary environments, the maximum design speed of most high-speed rail is 350km/h, while the design speed of alpine high-speed rail is mostly 200km/h-250km/h. In the initial stage of construction, the high-cold high-speed railway adopts different operation charts in winter and summer, with different operating speeds and different fares. As my country's first high-altitude high-speed railway, Harbin-Dalian High-speed Railway, this kind of operation plan was used in the initial stage of operation, and the unified operation diagram was used for driving after solving the corresponding technical problems in the later stage [4].

2.2.3 Effectively overcome the influence caused by temperature difference [5]

In alpine regions, high-speed railway rolling stock and other basic equipment will face a temperature difference of about 80°C. This puts higher requirements on the selection of equipment materials and disaster reduction treatment standards for alpine high-speed railways. Otherwise, serious safety accidents will occur. China's alpine high-speed train interior heating technology is in a leading position in the world. China has successfully kept the temperature inside the alpine train at around 22°C.

2.3 Alpine high-speed rail technical problems

2.3.1 Subgrade antifreeze technology

During the construction of my country's first alpine railway, the Harbin-Dalian high-speed railway, it was designed by China Railway First Survey and Design Institute. During the design process, the No. 1 Railway Institute fully drew on the existing technical achievements such as the Qinghai-Tibet Railway. Technological breakthroughs were carried out, and a ballastless track line test was carried out on the line. Through corresponding scientific research and line tests, the problem of "subgrade frost heave" was successfully solved.

2.3.2 Snow Blocking Technology

The equipment compartment of ordinary high-speed railway trains in my country is a semi-natural wind-cooled and semi-closed structure. There are many gaps in the structure when driving in the alpine region, and the high-speed train is prone to snow intrusion during high-speed driving. Due to the above situation, CNR has newly designed a naturally ventilated and sealed snow-proof equipment compartment. During a large number of experiments and applications, it has been found that the new type of vehicle can effectively prevent wind and snow from entering the equipment.

2.3.3 Condensate Treatment Technology

During the operation of the high-cold high-speed rail, it will enter the hot and humid environment from the low temperature environment. After the hot and humid water vapor meets the cold car body, the small ice cubes adsorbed on the lower part of the car body will melt, and there will be gaps between the car body equipment and pipelines. Corresponding treatment devices are installed on high-altitude high-speed railways to prevent the impact of condensed water on train equipment.

3. Safety operation and dispatch command of high-speed railway in alpine region

3.1 Safety operation strategy of high-speed railway in alpine region

3.1.1 Formulate overall operational thinking

The high-cold high-speed railway is mainly aimed at the safe transportation of passengers, so the high-cold high-speed railway must be people-oriented, take passenger service as the basic starting point of operation, and use high-cold trains as vehicles to provide passengers with safe, punctual, fast and comfortable passenger transport services. The high-cold high-speed railway takes passenger service as the core of its operation, command and management. Therefore, the high-cold railway operator needs to safely send passengers to the arrival station, and must also transfer with other modes of transportation at the arrival station, that is, within the station area. For example, short-distance transport vehicles such as subways, buses, intercity railways, and passenger buses can be provided. Around the whole process of passenger travel via alpine railway, it is necessary to implement integrated operation command and management of high-speed railway transportation. At the same time, grasp the operation information of the alpine railway line operation, the alpine high-speed railway infrastructure equipment, and weather changes along the line in real time, and grasp the actual operation status and construction plan of the operating equipment. Predict and handle weather and weather changes, coordinate emergencies and operational safety, and control around the elements of the passenger transportation system "man, machine, and environment".
3.1.2 Optimization of operation organization structure

In order to provide passengers with safe travel needs, the operation system of the high-cold high-speed railway should include an operation plan to optimize passenger operation services. Specifically, passenger service is the core of the operation work. Through comprehensive acquisition of operation information and comprehensive consideration of all aspects of operation, the operation plan is optimized in a timely manner to ensure the operation safety of the high-speed railway in cold weather. Since it is comprehensive coordination and cooperation at the top level, the planning department and relevant departments of passenger service should coordinate the arrangement of the operation plan.

3.1.3 Conduct new technology development for operating equipment

Since the high-cold high-speed rail needs to operate in harsh environments during operation, the high-cold high-speed trains need to overcome various difficulties compared with ordinary high-speed railways. For example: the impact of subgrade freezing on the stability of railway lines, the snow removal and snow melting work of railway turnouts in high cold weather, the impact and treatment of snow accumulation and freezing of catenary nets in high cold weather, etc. These difficulties require railway scientific research personnel to systematically research new technologies and develop corresponding new methods of operation to achieve the purpose of operational safety.

3.2 High-speed railway dispatching and command strategy in alpine regions

3.2.1 Comprehensive coordination of alpine high-speed railway dispatching

Analyze the operation of the alpine high-speed railway, and work with the alpine railway passenger transport department, dispatching station, and transportation department to make normal adjustments to the transportation capacity in different time periods such as off-season and peak season, comprehensively coordinate and determine the daily train operation map and adjust the dispatching plan. At the same time, understand the conditions of the alpine train drivers, train conductors, on-board mechanics, and alpine passenger operators along the way. If necessary, directly call to understand, grasp the live dispatching situation, and make accurate judgments. When the situation is abnormal, immediately discuss directly with the high-cold high-speed rail traffic dispatcher, make corresponding adjustment instructions, and accurately issue them to the operation and management department of the high-cold high-speed rail.

Systematic judgment is made based on the overall analysis of alpine railway line detection equipment and monitoring information management system, and comprehensive suggestions given after the operation information analysis of the corresponding railway technology center. Prepare the plan (operating conditions and technical standards) according to the operation diagram of the alpine railway line, confirm and approve the emergency, maintenance and adjustment and dispatching plan of the alpine railway line.

3.2.2 Guarantee the alpine high-speed railway dispatching in the whole process

Alpine railways need to maintain corresponding information exchange methods in real time with the railway transportation management departments that arrive at and stop at passenger stations along the line, and correctly direct the railway station dispatching department to coordinate and cooperate with the transportation management departments in the passing areas to ensure that passenger trains arrive and depart. In case of an emergency, it is necessary to directly coordinate with the local transportation management department to carry out passenger collection and distribution work together, and at the same time do a good job in the rescheduling of trains in emergency situations. In the event of an emergency beyond the authority of the railway and beyond its control, the station dispatching department shall report to the corresponding branch bureau leader, and at the same time suggest the adoption of urgent emergency procedures. After adoption, it should provide accurate information and correct decision-making suggestions for the leaders in charge to ensure the safety of railway dispatching.

3.2.3 Strengthen the self-control of railway personnel

The most basic purpose of dispatching and commanding the alpine railway is to ensure the safe operation of the alpine high-speed railway. At the same time, we also need to realize that, compared with other modes of transportation, alpine high-speed railway transportation has the following characteristics: First, the transportation volume is large; second, the transportation distance is long; third, the controllability is strong. Alpine high-speed rail dispatchers must develop a stronger sense of responsibility, have higher requirements for their own professionalism, earnestly grasp the relevant regulations of railway dispatching, carry out dispatching work in accordance with the principle of safe operation, and conscientiously perform their job duties. At the same time, railway dispatchers must conduct command work in strict accordance with superior standard dispatch orders, and analyze all dispatch information received in a timely and calm manner. Once a dangerous situation is encountered during the railway shunting process, calmly analyze the existing problems and find appropriate and correct handling measures to ensure the normal and safe operation of the high-speed railway in cold weather. Therefore, high-cold high-speed rail dispatchers must maintain good self-control, be able to combine theory with practice, and regulations with practical problems, and effectively provide a strong guarantee for the safety of high-cold high-speed rail dispatching.
4. Status of CT in Education

The transportation of alpine high-speed rail must be "people-oriented". Only under the premise of satisfying the safety of operation and dispatching can we explore new ways and methods to meet the convenience and comfort of passengers.

Regarding the operation and dispatching command of the high-altitude high-speed railway, safety is an eternal theme, which requires continuous research and development and active exploration by generations of railway personnel, and the development of new technologies is needed to ensure the safe operation and dispatching command of the high-altitude high-speed railway.

References