Discussion on intelligent monitoring technology of railway wagon

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Abstract. In the actual transportation process, a series of bad conditions could occur due to the unexpected opening of the door. This paper introduced the current situation of railway transportation process; analyzed the advantages and necessity of intelligent monitoring system; Then taking the boxcar as an example, the basic process of intelligent real-time detection is proposed; and the problems that may need to be considered in the actual implementation process are summarized.

1. Research Background

Railway transportation has the advantages of high efficiency, safety, and convenience. At the same time, it also has the characteristics of large-scale transportation, complex business, and wide geographical coverage. In railway transportation, cargo transportation occupies an important position, and the vehicles carried in cargo transportation are called railway wagons. According to the different purposes of transport vehicles, railway freight wagons can be divided into special and general freight trucks. Commonly used railway wagons include gondola cars, box cars, flat cars, tank cars, etc. Among them, the boxcar is a vehicle with enclosed compartments used to transport high value-added goods. Due to the enclosed nature of its compartments and the complexity of manufacturing design, it is often used to transport valuable goods that are vulnerable to rain, and has a certain degree of safety. However, during transportation, if the door of the boxcar is not closed properly, the door will fall off, the goods may be stolen, the equipment signal may be damaged, and the running safety may even be endangered. At present, the railway transportation system is accompanied by the rapid development of detection technology, communication technology and intelligent technology. In order to avoid the occurrence of bad conditions of goods falling from the running train during transportation, safety monitoring technology and timely feedback system during the transportation of goods has been more and more paid attention to research. In recent years, foreign intelligent railway transportation systems have developed extensively, but intelligent railway transportation systems in China are in need of self-breakthrough under the three major goals of convenience, speed and intelligence, vigorously build intelligent railway transportation systems with Chinese characteristics, and provide security operation for railway transportation [1].
2. Research Content

2.1 Analysis on the Current Situation of Railway Freight Wagons Intelligence

According to relevant information: In 2019, the total volume of national railway transportation and freight transportation was 4.389 billion tons, an increase of 7.2% compared with 2018 [2]. It can be seen from the above data that the importance of railway freight transportation is becoming more and more prominent, and the safety of railway transportation should also arouse attention, and the intelligentization of railway freight wagons has also emerged. At present, railway wagons intelligent system in China is still in the development stage because of its late start compared to the mature foreign countries. However, with the rapid development of related technologies such as measurement technology, communication technology, and Internet of Things technology, the intelligent safety monitoring system for railway wagons in China is gradually improving, and some good achievements have been made. In recent years, many technicians have made a lot of contributions in the fields such as monitoring the transportation status of railway trucks, monitoring the overrun status of railway goods, monitoring technology along the railway transportation of dangerous goods, and automatic monitoring of boxcar doors and laser monitoring. Therefore, the research on the intelligent monitoring technology of railway wagons operation safety should be persistent.

2.2 Necessity of Intelligent Railway Wagons

With the development of "high-speed, heavy-duty" trains, it is especially important to manage railway freight, especially the real-time monitoring of railway wagons in operation, and to grasp the operational safety status of vehicles in time. At present, in the process of railway freight transportation, the traditional operating procedures of mechanical sealing (such as lead sealing) at the departure station, inspection and replacement at the intermediate station, unsealing and inspection at the station are used to ensure the safety of the goods being transported. However, in the actual operation of the railway, on the one hand, due to the remote route of the train, the complex terrain along the way, the numerous tunnels, and the long line, some road sections are prone to theft, etc., which will affect the quality and quantity of cargo transportation on the train; on the other hand, in the process of train transportation, the trains are equipped with limited guards, which makes it difficult to find the trains in time after the train is broken, resulting in the loss of goods or the scattered goods on the railway line, which poses a serious threat to the safety of railway transportation. According to relevant information: At 0:50 on April 25, 2006, when the No. 25431 train drove to K449 + 290 meters between Shamalada and Wazhu on the Chengkun line, the suspect climbed into the 25th boxcar after the locomotive and dropped 8 bundles of white cloth from the carriage, causing the 26th to 28th and 31st to 37th vehicles to subvert, the 30th vehicles to derail, and it is a major accident that interrupted driving for 16 hours and 59 minutes [3]. Therefore, in order to ensure the safety of freight trains, it is urgent to develop a safety management system that can strictly monitor the operation of freight trains and grasp the transportation status of each train in time.

3. Solutions

3.1 Intelligent Transportation Monitoring System

The main content of this research is to organize and comprehensively analyze the accidents that may occur in the actual transportation of traditional railway freight cars. It can be seen that if the door of a boxcar and other railway truck is not closed properly during transportation, the door will fall off, the goods will be stolen, or the equipment signal will be damaged, pedestrians will be injured, and driving safety will even be endangered. In addition, if the goods transported by the railway wagons exceed the boundary, the related signal equipment will be damaged, and even the entire signal will be interrupted. When the train driver discovered this series of serious consequences, it has caused an irreversible situation. Therefore, in order to ensure the safety of freight trains, it is necessary to add an intelligent monitoring system to the traditional railway freight transportation system. This not only ensures the
safe driving of the train, but also allows the train driver to monitor the status of the vehicle in transit in real time. After the railway freight car has an intelligent automatic monitoring system, it can not only monitor the train doors and the entire body in a highly efficient and all-round way, but also ensure transportation safety and avoid theft, which has good economic benefits. Intelligent control systems are advanced technologies such as monitoring, big data and information networks, and develop a set of intelligent power supply and intelligent monitoring systems for railway wagons. It can realize omni-directional dead-angle monitoring of railway wagons, especially high value-added cargo (white cargo) trains, as well as monitoring of key components such as doors and bogies of vehicles to ensure the safety of vehicle operation and cargo. It is convenient for railway freight management personnel to real-time management of railway wagons and transported goods. The system includes several parts such as railway truck power generation device, railway truck intelligent power supply management system, performance data monitoring and early warning system, fire and anti-theft safety monitoring and early warning system. The following is based on the research of the box car door, and the signal acquisition implementation diagram is as follows.

![Diagram of boxcar intelligent monitoring](image)

1-boxcar carriage; 2-door; 3- ranging sensor

Figure 1 Basic implementation diagram of boxcar intelligent monitoring

Referring to Fig.1 to illustrate the basic implementation process of the intelligent monitoring system for this subject. The main working part of the system is the number 3 ranging sensor part in the figure. When the door latch is accidentally opened, the two doors will have serious consequences such as vibration during driving, causing the goods to fall, stolen, and hurt pedestrians after the doors are opened. The function of the ranging sensor 3 is: When the door is opened due to an accident and the distance between the two doors exceeds the distance set by the distance measuring sensor, the alarm in the train cab will send out an alarm signal. After the driver receives the alarm information, he will deal with it in time according to the actual situation. This can not only ensure the safety of cargo transportation, but also prevent other signal equipment along the road from being damaged by accidental falling of the cargo.

In the actual implementation process, some influencing factors need to be considered such as: Factors such as the appropriate actual location of the distance sensor installed near the door bolt, the convenience of unloading, and the accuracy of distance measurement.

3.2 Intelligent transportation monitoring power supply system

Aiming at the power supply problem of the intelligent monitoring system of the boxcar, the power-taking device can be installed in the proper position of the bogie, as shown in Fig.2(a). On the basis of not affecting the original design of the wheelset, two sets of cam devices are connected by bolts to drive the linear reciprocating coaxial electric field induction generator to generate induced current, and then complete the power supply task for the intelligent transportation monitoring system.
According to the schematic diagram of the power supply system in Fig.2(b), the obtained electric energy $W$ can be calculated by combining the following formula:

$$W = K \times \left(\frac{V}{R \div \pi} \right) S^2 \times \eta$$  \hspace{1cm} (1)

In the formula, $K$-cam follower return spring coefficient; $S$-cam return; $V$-train speed; $R$-wheel radius; $\eta$-mechanical efficiency.

Fig.3 Working principle diagram of integrated control cabinet
The control process of the intelligent transportation monitoring power supply system consists of the part above point A shown in Figure 2 and the control system, integrated into a control cabinet, which is installed in the vehicle body. The working principle diagram of this integrated control cabinet is shown in Fig.3. In the figure, the power-taking module is equipped with an induction power-taking part, which includes a permanent magnet 1 and a current transformer 2. The current transformer contains a power-taking coil; it is connected in parallel with the variable resistor 3 and the fixed resistor 4, and is connected to the rectifier circuit 5; the rectifier circuit 5 is also connected to the single-pole double-throw switch 8, the transformer bleeder circuit 6, the resistance bleed circuit 7, the first filter capacitor 15, the second filter capacitor 16, and the voltage stabilizing circuit 9; the voltage stabilizing circuit 9 and the load 17 are connected in parallel. From variable resistor 3 to load 17 are integrated in the control cabinet. The monitored objects are collected, analyzed, and processed (including sending) to the same single-chip microcomputer for unified analysis and control. Then send the processed results to the driver's cab and station respectively. In this way, drivers and related personnel can timely monitor the transportation process of the entire freight train through the intelligent transportation monitoring system.

4. Conclusion
This topic mainly solves the problem of a series of undesirable phenomena caused by the falling of the goods due to some accidents during the actual transportation of the railway train (boxcar). An intelligent detection system device is proposed. This device can detect the opening of the entire train door in real time, and feedback the monitoring information to the control center and train driver in time to facilitate timely processing and improve train safety. In addition, it also solves the problem of the power supply system of this intelligent transportation monitoring during driving. The intelligent detection system proposed this time has many shortcomings that need to be considered. It needs to be further engineered and expanded to a wider range of monitoring. It can be further improved during the actual operation of the site.

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