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Design and Application of Intelligent Control System for Molten Iron Transportation Based on 5G Technology

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Abstract: Molten transport is an important link in the iron and steel enterprise production, involves many complex factors, artificial management is difficult. Therefore, puts forward a kind of molten iron transport wisdom control system based on 5G technology, which mainly contains the intelligent identification tracking system, equipment status collection information acquisition system, locomotive vehicle terminal system, etc. Combined with the analysis of the actual application situation, the system could integrate all the processes and elements of molten iron production and transportation, realize the integration of operation and management, and also promote the improvement of the turnover efficiency of molten iron tank, reduce the demand for personnel, and reduce the labor cost.
Keywords: 5G technology; molten iron transportation; intelligent control system

Introduction

From the perspective of improving the efficiency of molten iron transportation and ensuring transportation safety, corresponding intelligent control systems can be established with the help of 5G technology, artificial intelligence technology, etc. This system is responsible for intelligent planning of the transportation path of molten iron, cooperating with sensors to collect real-time information on the transportation path, and making automatic adjustments based on actual situations to avoid road sections that may affect transportation operations. Practice has proven that building a smart management and control system for molten iron transportation has a very positive significance in improving the efficiency of molten iron turnover and achieving cost reduction and efficiency increase.

1 Problem analysis

Currently, in the transportation of molten iron in steel plants, the application of automation and intelligent technology is relatively insufficient, making it impossible to accurately identify and track the actual operation trajectory of the molten iron tank. Many aspects of the information need to be manually fed back, which has a certain degree of disconnection from the actual situation on site. There is a serious inconsistency between the information flow and the actual logistics. In addition, there is a cross phenomenon in the distribution mode of molten iron, which has not been effectively solidified, resulting in a relatively unbalanced state of steel production [1].

In response to such issues, steel companies can establish an intelligent control system for molten iron transportation, supported by intelligent control, to achieve the goal of minimizing the cost and time of molten iron transportation. In the practical stage, two key issues must be addressed first: the first is the problem of path selection. When selecting the transportation path for molten iron, theoretical methods related to graph theory can be used to simplify the transportation network, use mathematical language to describe the transportation network, construct the corresponding network topology model, combine Dijkstra

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algorithm, determine the static path for molten iron transportation, and then compare the specific transportation situation to make dynamic adjustments to the path. The second issue is collision avoidance. Effective avoidance of collisions is necessary during locomotive operation. It is possible to schedule transportation sections in advance and occupy corresponding transportation sections, set up corresponding collision detection models, and ensure that during the transportation process, possible collision sections can be predicted, and collision avoidance measures such as waiting and giving way can be taken. The specific method to be adopted needs to be determined based on the actual situation on site [2].

2 System design

2.1 System architecture

According to different functions, the system is mainly divided into four components: the first is the information display section, which can visually display relevant information in all processes of molten iron transportation, including data indicator information, spatial dimension information, time dimension information, model operation information, and scheduling job information [3]. The second is the intelligent control part, which is also the core component of the system, with rich functions, such as intelligent allocation of molten iron, intelligent scheduling of locomotives, intelligent planning of transportation routes, and automatic arrangement of routes. The third part is the basic automation part, including the collection of status information at the steelmaking end, visual recognition and tracking of molten iron tanks, 5G onboard terminals, and precise positioning of locomotives. The fourth is the external interface part, including manufacturing management system, measurement system, ironmaking/steelmaking system, and microcomputer interlocking system [4].

2.2 System function

2.2.1 Intelligent recognition and tracking system

In order to track and manage the transportation process of molten iron, taking into account the actual production environment of the steelmaking plant, corresponding QR code labels are set up on the molten iron tank as identification marks. The QR code is made of steel plate material, which has the characteristics of high temperature and corrosion resistance. The surface steel plate adopts a hollow structure to form a QR code pattern, which is relatively light in color and the back plate has a darker color, This can better display the patterns on the surface board. In the transportation of molten iron, it is necessary to install corresponding visual recognition equipment in some key areas, such as the blast furnace tapping hole and main intersections. This way, when the molten iron tank passes through, the equipment can collect its QR code information and convert it into recognition information. Through the 5G network, it is transmitted to the scheduling system to achieve effective collection of information for each link [5].

2.2.2 Vehicle terminal system

The onboard terminal system is mainly responsible for locating locomotives and inputting work instructions, and includes multiple functional modules:

(1) Positioning module. The main function of the positioning module is to clarify the specific location of the locomotive. Its main function is to receive and organize the information transmitted by sensors, cooperate with professional algorithms and technical means, determine the precise position of the locomotive, and provide comprehensive and accurate position information for various operations in system operation.

(2) 5G module. The MEC private network is used here, which can achieve high-speed transmission of information between the vehicle terminal and the system.

(3) HMI module. This module mainly displays the operation interface and provides corresponding operation and feedback functions, such as receiving transportation instructions, task execution feedback, positioning information display, traffic signal display, etc. For some important areas of road intersections, corresponding intersection control functions will also be provided [6].

2.2.3 Road crossing control system

In the past, in the transportation of molten iron, in order to ensure transportation efficiency and avoid collision problems, personnel were required to be arranged to command at major intersections, resulting in wastage of human resources. The road control system can achieve unmanned and intelligent control, which integrates 5G communication technology, microcomputer interlocking technology, GNSS positioning technology, etc. It can create corresponding intelligent control models based on locomotive positioning information, iron transportation plans, etc., to achieve intelligent judgment of whether the locomotive has passed the intersection. When the distance between the locomotive and the intersection reaches or exceeds the set value, the alarm information will be automatically triggered or lifted, Thus achieving intelligent control of road intersections. By combining 5G communication technology, real-time and rapid transmission of various information can be achieved, and it can be visually displayed on the onboard terminal screen, helping drivers better observe the surrounding environmental information and effectively ensuring the safety of molten iron transportation.

2.2.4 Hot metal scheduling system

The intelligent scheduling system consists of multiple

models, and it is necessary to do a good job in model construction. Starting from the actual needs of molten iron transportation, it is necessary to promote the continuous optimization and improvement of the models.

(1) Prediction model. The main approach is to predict the demand for molten iron by combining corresponding production and demand plans. At the same time, the blast furnace production algorithm model is used to predict the molten iron production of the blast furnace, and based on this, the supply and demand relationship of molten iron is determined, providing reference for the formulation of molten iron transportation plans.

(2) Allocation model. It is necessary to determine key parameters based on actual production, including priority of steelmaking consumption, priority of blast furnace iron separation, etc., to provide intelligent guidance for the allocation of molten iron.

(3) Can configuration model. Technicians must combine the iron production plan and production situation, based on big data technology, to create an intelligent tank allocation model, determine the best tank allocation plan, and ensure the rationality and effectiveness of tank allocation. In practice, different tank allocation models can be set for different blast furnaces.

(4) Scheduling model. Corresponding scheduling algorithm models can be used to automatically generate transportation tasks for molten iron tanks based on production conditions, and real-time online monitoring of the actual execution status of the tasks can be carried out. If any task overruns are found, the system will automatically issue an alarm message to the staff.

2.2.5 Locomotive dispatch system

In the locomotive dispatch system, there are two key models: the first is the path planning model, which mainly compares the operation plan of the locomotive itself, cooperates with the path planning algorithm, and plans the locomotive operation path. By interacting with the real-time position information of the locomotive, collision detection and avoidance can be achieved. The second is the locomotive scheduling model, which can combine the different operation types and areas of each locomotive to determine the corresponding operation priority. This priority has dynamic characteristics and is not fixed. The model can determine the actual location and task priority of the molten iron tank according to the corresponding scheduling instructions, and combine the intelligent analysis of the model to determine the locomotive that can undertake the molten iron transportation task. After determining the specific number of the locomotive, the model will automatically generate the corresponding locomotive's operation plan and transmit the plan to the corresponding locomotive's onboard terminal. It can also monitor the actual completion of the task and transmit the results of the task completion to the scheduling iron scheduling system. With the help of locomotive dispatch system, remote control of locomotives can be achieved, achieving unmanned automatic transportation. In case of emergencies, timely intervention can also be made to ensure the safety of molten iron transportation [7].

2.2.6 Visualization system

On the basis of in-depth analysis of the transportation data of molten iron, relevant reports are established and visually displayed in the form of graphics. The reports here include the turnover rate of molten iron tanks, locomotive operation efficiency, and intersection occupancy efficiency. The system is able to monitor key indicators in the transportation of molten iron. When there are abnormalities in the indicators, timely warnings are issued to help staff handle them in a timely manner, promoting optimization and innovation in the organization of molten iron logistics.

3 System applications

Compared with the actual situation of steel mills, the intelligent control system for molten iron transportation based on 5G technology plays an important role in application, which is reflected in:

(1) The foundation of automated management for molten iron production and transportation has been strengthened, which can track the position of molten iron tanks and locomotives during the transportation process, and visually present their true status.

(2) All relevant processes and information related to the production and transportation of molten iron have been integrated, effectively eliminating the barriers between interface management and data management in production, and achieving automation, intelligence, and integration of operation management.

(3) By utilizing various intelligent models, such as automatic route arrangement models, locomotive intelligent scheduling models, and unmanned control models at intersections, the demand for intersection personnel and signalmen can be reduced, and centralized operation management can be achieved. While improving the turnover efficiency of molten iron tanks, the degree of temperature drop during transportation can be reduced, which can also help steel mills reduce staff and increase efficiency.

(4) Under the effective application of the intelligent control system for molten iron transportation, it can significantly improve work efficiency, reduce labor costs in molten iron transportation, enhance the safety of molten iron transportation, and have good economic and comprehensive benefits [8].

4 Conclusion

In summary, steel enterprises have high requirements for the efficiency of molten iron transportation in actual production. Based on 5G technology, combined with sensor technology, artificial intelligence technology, etc., a corresponding intelligent control system for molten iron transportation has been established, and the actual application of the system has been analyzed. The results show that, with the reasonable application of intelligent control systems, the problems existing in traditional iron transportation can be solved, and the efficiency and safety of iron transportation can be improved.

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