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Dumper Hopper Automatic Feeding Technology and System Development

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Abstract. With the advancement of the construction of world-class ports and smart ports, informatization and intelligence have become an important means to improve the efficiency and safety of port operations. In this paper, the dumper of dry bulk cargo terminal is taken as the object, and the key technologies such as automatic adjustment of the vibration feeder of the dumper, monitoring of the train at the entrance and exit, intelligent monitoring of the material level of the hopper, and monitoring of the material flow of the belt conveyor are studied. The automatic feeding system of the hopper of the dumper is developed to realize the automatic feeding of the dumper, to achieve uniform and stable material flow, greatly improve the operation efficiency of the dumper, and support the automatic operation of the whole process of the dry bulk cargo terminal.

Keywords: smart port, car dumper, vibration feeder

1. Introduction

Dumper is a large and efficient mechanized unloading equipment for dry bulk cargo terminal to dump railway gondola cars. The hopper feeding system of dumper is an important part of dumper. It is generally composed of hopper, hopper level meter, vibrating feeder, belt scale and so on. The feeding speed of the system is a key link to determine the efficiency of unloading operation [1]. In recent years, the port has actively carried out research on the automation and high efficiency of the dumper hopper feeding system. Yang Yafeng et al. [2] proposed an automatic feeding control scheme for intelligent construction and automatic correction of feeding parameters, which realized the intelligent construction and automatic correction of feeding parameters in the automatic feeding operation of the dumper. Han et al. [3] optimized the operation speed of the dumper and the positioning vehicle, the operation process of the pressing / leaning device, the feeding system and the material detection system, and the feeding operation efficiency was significantly improved. Gao et al. [4] using multi-sensor information fusion technology, the strain sensor, passive nuclear material level meter and mercury tilt switch used in the dumper hopper level monitoring are processed by multi-level information complementarity and optimization combination, which improves the accuracy of the dumper hopper level detection. With the deepening of the construction of world-class ports and smart ports [5], new requirements have been put forward for the operation efficiency and automation level of the dumper, so as to realize the full automation control of the

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hopper feeding of the dumper through the new generation of information technology such as artificial intelligence and intelligent perception.

2. Tumper hopper automatic feeding system composition

The automatic feeding system of dumper hopper (hereinafter referred to as " automatic feeding system ") can automatically adjust the feeding amount of each hopper according to the set flow rate of the conveyor belt machine, so as to realize the constant and stable feeding flow of the belt machine. The hardware of the system is composed of the vibration feeder of the car dumper, the intelligent scanning system of the entrance and exit trains, the level radar and weighing sensor of the car dumper hopper, the belt scale of the car dumper, the intelligent scanning system of the material flow of the belt conveyor and other components. At the same time, the automatic feeding program of the car dumper hopper and the remote monitoring system of the car dumper in the central control room are integrated. Each component cooperates with each other to realize the full automatic feeding of the car dumper hopper.

3. Automatic adjustment technology of dumper vibrating feeder

Based on the adjustment function of the dumper to the vibration feeder, the remote control system automatically adjusts the vibration feeder. The automatic / manual feeding selection mode knob of the dumper is set in the dumper control room. When the dumper is selected for automatic feeding, the start and stop of the vibration feeder and the gate opening are controlled by the remote control operation terminal of the dumper in the central control room, and the dumper control room cannot be involved in the operation. When the manual feeding of the dumper is selected, the remote operation of the dumper in the central control room cannot work, and the start and stop of the vibration feeder and the gate opening are manually adjusted by the on-site dumper control room. In the automatic feeding mode of the dumper, the vibrating feeder automatically adjusts the amount of material according to the capacity of the material in each hopper, and realizes real-time monitoring of the material level during the unloading process to eliminate the phenomenon of emptying and excess of the hopper. The automatic feeding system independently monitors the high level signal of the hopper and interlocks with the positioning car and the dumper body to stop the dump operation.

4. Intelligent scanning monitoring technology of train at the entrance and exit of car dumper

The intelligent scanning system of the train at the entrance and exit can scan the train in and out of the dumper in real time, and display the digital model of the train. It is mainly composed of 2D laser scanner, signal acquisition device of the dumper positioning car / car pusher, train scanning data server and monitoring operation terminal. The system uses a variety of visual scanning technology to achieve integration. The field device acquisition terminal uses OPC (OLE for Process Control) communication specification, uses C + + to write the front-end acquisition module, uses HTML5 to develop the application front-end, and embeds WebGL technology to achieve real-time data, historical data three-dimensional rendering and display. The main functions include : detection of foreign bodies in the entrance car, emptying of goods in the exit car, damage state of the inner components of the car, and collection of coal density for single-row mass calculation of the track scale. The installation position of the laser intelligent scanner is shown in Fig.1 and Fig.2.

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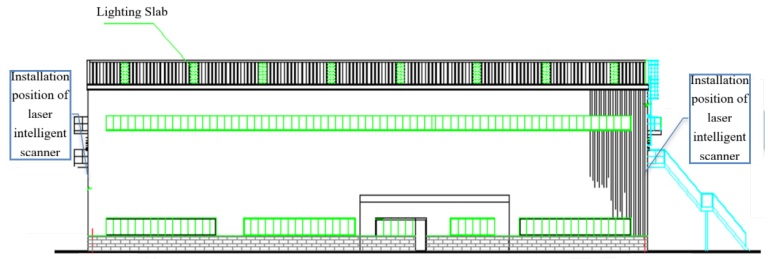

Figure 1. Installation position diagram of laser intelligent scanner



Figure 2. On-site installation location of laser intelligent scanner

The main workflow of the train intelligent scanning system at the entrance and exit is as follows: After the dumper positioning vehicle completes the first train alignment, it issues instructions to the train scanning system when preparing for the operation. The laser intelligent scanner scans the train, and the real-time data is transmitted back to the train scanning server. The data server generates the model in the compartment according to the collected point cloud information, and processes and analyzes the information such as foreign objects in the compartment, and displays it in real time on the terminal of the central control room for the operator to browse, which can provide early warning and alarm information in real time.

The intelligent scanning system calculates the density of unloading coal and other information by collecting the data of heavy rail weighbridge and combining the digital model of the carriage after

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scanning, and pushes the statistics of the automatic feeding system. When the empty car is pushed out of the car dumper by the car pusher, the laser intelligent scanner installed at the outlet scans the empty car in real time, and sends the real-time data back to the train scanning server. The data server generates the model in the car according to the collected point cloud information. Through processing and analysis, it is judged whether the material in the car is unloaded, and whether the reinforced bar in the car is damaged and fallen off. It is displayed in real time at the terminal of the central control room for operators to browse. The compartment model generated by the intelligent scanning system of the train at the entrance and exit is shown in Fig.3.Fig.a is the full carriage model and Fig.b is the empty carriage model.

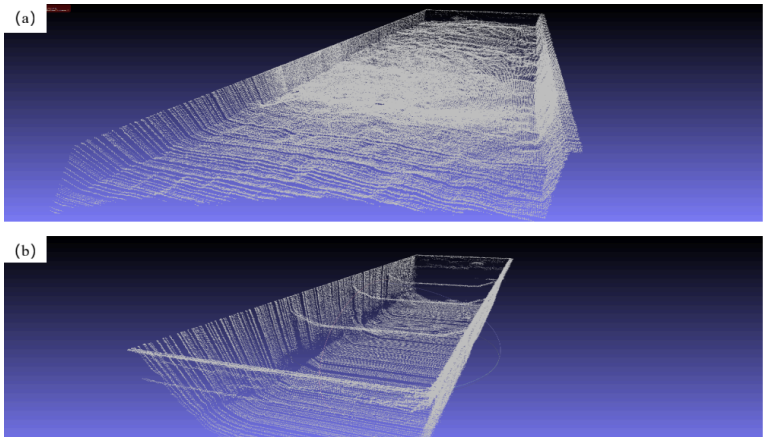

Figure 3. In-car model generated by train intelligent scanning system(a) full carriage model; (b) empty carriage model

5. Dumper hopper level monitoring technology

The radar intelligent level meter is arranged above each hopper of the dumper to monitor the material level in the hopper of the dumper in real time. The radar signal of the level gauge is collected by the dumper PLC, and the material height in the hopper can be fed back to the remote monitoring system of the dumper in real time, which is used to automatically adjust the hopper feeder of the dumper, so as to realize the automatic adjustment of the feed amount of the belt conveyor according to the material amount in the hopper. The detection distance of the radar material level meter is 120 m, the error is less than ± 5 cm, the focus is good, the signal is strong, and the strong dust and moisture can be penetrated. On-site collection and remote transmission to the central control room operation terminal, and real-time display of the material height in the hopper, and through the remote monitoring system of the car dumper, real-time adjustment of the vibration feeder to achieve stable belt conveyor traffic and uniform feeding.

The size of the hopper grate of the dumper is 400*400 mm, and the radar intelligent level meter is installed at a height of 8 m. The signal range projected on the grate is about 0.9m in diameter and can pass through 4 grids. According to the field test, the feedback signal energy is partially attenuated, but the actual signal range is much larger, which can meet the effective measurement of the material height in the hopper by the level gauge, as shown in Fig 4.

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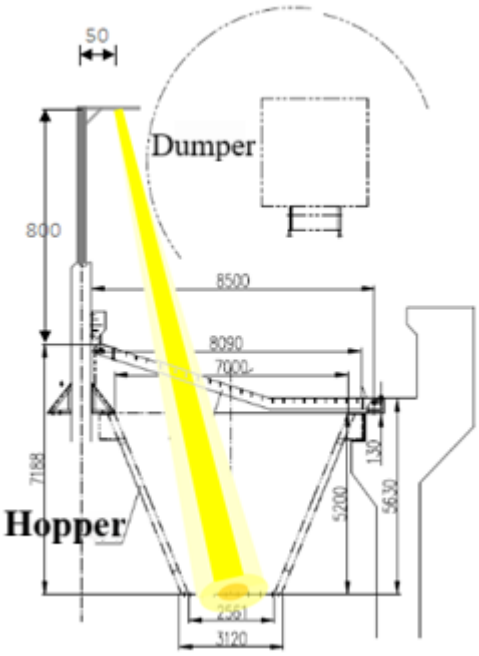

Figure 4. Installation position of dumper material level radar

The material level monitoring of the dumper is generated in real time by the field data of the radar intelligent material level meter and the hopper weighing sensor, which is the main function of the dumper hopper automatic feeding. The local control system of the dumper takes the hopper weighing sensor as a reference to control the equipment. The remote monitoring of the dumper is based on the data of the radar intelligent level meter and the hopper weighing sensor. Through the logic program judgment, the height of the material level in the hopper is determined, and the automatic feeding operation of the dumper hopper is realized.

6. Dumper conveyor belt conveyor material flow monitoring technology

A set of laser intelligent scanner is arranged above the belt conveyor to monitor the material flow on the belt conveyor in real time. Combined with the instantaneous flow of the belt scale, a closed-loop control is formed to realize the automatic adjustment of the feeding amount of the automatic feeding system and meet the maximum capacity of the belt conveyor, as shown in figure 5. The intelligent scanning system of belt conveyor material flow also adopts the same brand of laser intelligent scanner as the intelligent scanning system of entrance and exit train. The scanning mode is the same. The intelligent scanning system of belt conveyor material flow can be directly connected to the remote monitoring system of car dumper, and interlocked with belt scale and feeder to realize the automatic and uniform feeding of car dumper.

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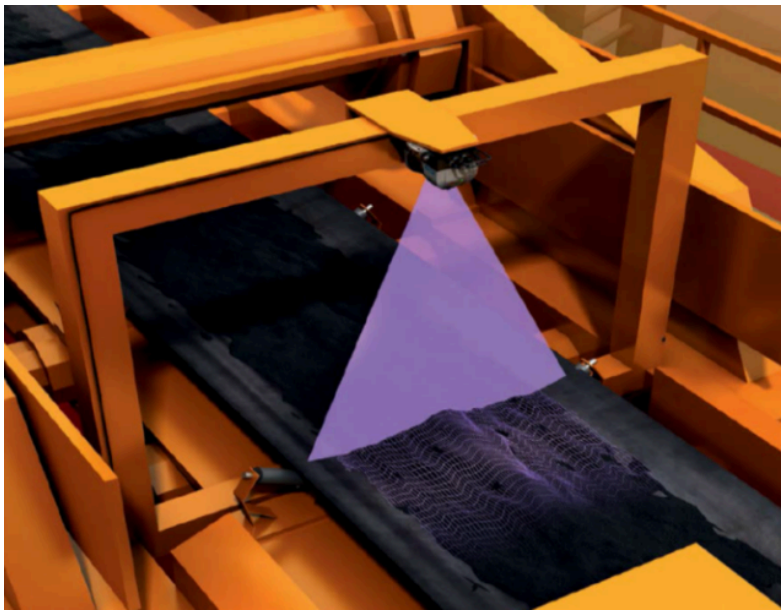

Figure 5. Installation of material flow scanning equipment for conveyor belt conveyor

7. Conclusion

After the automatic feeding system of the dumper hopper is adopted, the full automatic feeding is realized because the unloading amount is based on the feedback of the on-site detection equipment, which can achieve uniform and stable material flow, reduce the influence of blocking and scattering caused by unstable material flow, effectively reduce the number of system shutdown faults, greatly improve the efficiency of the dump operation, and reduce the cost of equipment maintenance and maintenance. At the same time, the application of the automatic feeding system of the dumper hopper, the central control room does not need to be equipped with a special person to remotely monitor the dumper, and the remote operator of the stacker can cooperate to complete the monitoring of the dumper.

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