Research on operation safety management of the belt conveyor in ore terminals

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Abstract. The ore conveying system of Rizhao Port Group Lanshan Port Co., Ltd is currently the most widely used system in China with large capacity pipe belt conveyors. Because the conveyor system has the characteristics of long path, high power, many types of components and many key control points, the safety management of the system is essential to production and operation. Through the introduction of system composition, management mode and technological innovation, this paper expounds the promotion effect of safety management and control mode reform, safety supervision technological innovation and maintenance process optimization on safety management of the conveyor system.

Keywords: Ore belt conveyor system, Safety management, Maintenance process.

1. Introduction

Belt conveyor system are widely used in dry bulk transportation in ports, power plants, steel mills, etc. Because of its green, environmental and high-efficiency characteristics, it has become the main carrier for bulk cargo transportation in ports. The ore belt conveyor system of Rizhao Port Group Lanshan Port Co., Ltd is a professional and automated conveying system that integrates the function of ship unloading, stockpiling, transshipment and ultra-large capacity tubular belt conveyors. Its main function is to realize the transportation of iron ore from the Lanshan port area to the two steel plants of Shandong Iron and Steel Group Rizhao Co., Ltd. and Rizhao Steel Holding Group Co., Ltd. In recent years, as the two major steel plants continue to expand their capacity and increase the demand for ore materials, the ore belt conveyor system has played an important role in alleviating urban road traffic pressure, reducing environmental pollution, and promoting green development, which produced the significant economic and social benefits.

The ore belt conveyor system is mainly composed of 5 tubular belt conveyors, 18 belt conveyors, 3 ship unloaders, 6 stacker-reclaimers. The ore belt conveyor system is about 24.5km long and linked by 15 transfer stations. A single tubular belt conveyor is 3.6 kilometers long.

The ore belt conveyor system has the characteristics of multiple points, long lines and wide areas. A problem in a certain link in the system will have a greater impact on the overall operating efficiency and safety of the system. Small accidents will cause the system to temporarily stop production, and large accidents will cause machine damage accidents and even personal injury. The safe operation of the system has become the top priority of port safety production management and supervision. In the port production, a combination of management mode and technological innovation is adopted. Through the reform of safety control mode, the innovation of safety supervision technology and the optimization of maintenance process, the unmanned patrol inspection, fault identification and intelligent monitoring of the ore belt conveyor system are formed, which greatly improves the safe and efficient operation level of the system.

2. Reform of safety management and control model

Due to the long-distance transportation of the belt conveyor system, it is easy to cause various failures, such as belt deviation, material scattering, slipping, abrasion, abnormal noise, etc. It requires

manual on-site inspection to monitor its operation status in real time. The inspectors mainly rely on the vision and hearing, and often go back and forth between the head and tail of the belt conveyor system. The complicated environment of the belt conveyor system increases the labor intensity of the inspectors and also increases safety risks. Based on the above situation, on the basis of studying the traditional manual inspection method, combined with the actual situation of the production business, the inspection mode of the ore belt conveyor system is researched and reformed. The comprehensive closed isolation, the complementary two-level monitoring, the real-time and accurate personnel positioning and other means have been adopted. The on-site equipment and facilities, production operations, and maintenance operations are fully monitored.

2.1 Classification of safety management and modularization of supervision areas

By increasing investment in information technology such as video surveillance and using "electronic eyes" instead of "human eyes", the optimization and upgrading of the central monitoring system's management mode has been completed in three steps.

The first step is to increase the coverage of the video surveillance system. By using high-definition digital surveillance, the layout of the high-definition surveillance cameras is fully optimized. The video surveillance of the key parts in the belt conveyor and the risk points above the two-level is fully covered. All-round safety management of the ore belt conveyor system is realized.

The second step is to implement on-site secondary monitoring management. Based on the comprehensive management of the central monitoring system, three second-level monitoring rooms (which can be modularly expanded according to the scale) were built on the site to allow implement key management in the respective areas. Therefore, a two-level safety supervision model of a central supervision system and an on-site supervision system can be formed. The complementary system of safety management can be realized.

The third step is to achieve modular management of the regulatory area. In order to reduce the amount of monitoring image switching and monitoring tasks, the monitoring screens are sorted and classified according to the transportation process and importance, and the monitoring area is modularized. Through the above operations, the first-level monitoring position is fixed and displayed in real time, the second-level monitoring position is displayed in multi-point scrolling, and the screen is displayed in levels and processes, which overcomes the complicated problems of monitoring and inspection tasks.

2.2 Dynamic monitoring of man-machine status to achieve "three-in-one" safety management

The unsafe state of machines and the unsafe behavior of persons are the causes of production accidents. The effective isolation between machine and person can minimize the safety risk caused by personnel breaking into and touching the machine, and improve the safety within the contact range of the belt conveyor. Through the investigation of on-site safety risks and the formulation of regional safety plan, the means of risk identification, patrol route closure and transfer station closure are applied to realize the physical isolation of export safety risk sources.

Based on the effective control of external risk factors, the Bluetooth + GPS positioning system is used to dynamically and accurately locate the on-site operators in real time, so as to ensure the safety of the the on-site operators. Each on-site operator wears an electronic positioning card, which can view the position and track to realize real-time tracking, guidance and reminding to the operator. In combination with the "Prohibition" in the safety management rules and regulations and the risk prompt of the safety emergency management plan, the on-site dangerous operation area should be controlled to ensure personal safety. The control effect is shown in Figure 1.

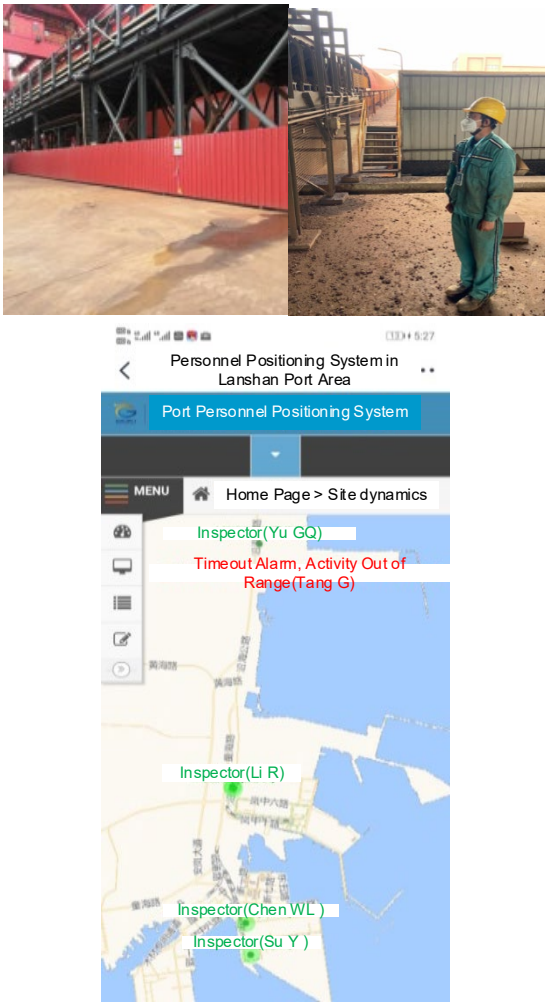


Fig. 1 "Three-in-one" safety management

With the implementation of the above multiple measures, the inspection coverage and efficiency have been greatly improved. The allocation of the inspection personnel has been reduced by 50%, which improves the work efficiency and reduces the probability of on-site man-machine cross operation. It greatly reduces the risk sources of potential safety hazards.

3. Innovation of safety management and control technology

The operation stability and the reliability of safety protection device are the basis of the ore belt conveyor system. Through the innovation of safety management and control technology, the information and intelligent means has been applied to provide safety lock for the healthy operation of the ore belt conveyor system. It can strengthen improve the operation stability and the reliability of the ore belt conveyor system.

3.1 Technology of intelligent inspection robot

In order to improve safety management and reduce man-machine cross operation points of the ore belt conveyor system, intelligent inspection robot was applied in the operation and management of the system for the first time, which explored a new way for unmanned inspection of similar projects in China.

By using infrared thermal imager, HD camera and pickup device, the intelligent inspection robot embeds sound sensor, image sensor, temperature and humidity sensor and smoke sensor into the body to imitate the "listening, seeing, smelling and touching" behavior of manual inspection. Environmental conditions and system status are inspected regularly, as shown in Figure 2. The

inspection data can be transmitted to the central control system in real time to provide decision-making for system inspection and maintenance plan. This technology can realize the man-machine separation, decreases the difficulty of long-distance operation at high altitude, reduces personnel operation risk, labor intensity and saves labor cost.



Fig. 2 Intelligent inspection robot

3.2 Replace "manual operation" with "intelligent control", achieve unmanned operation of stacking machinery

The operations of the raditional stacker are usually carried out manually. The stacker driver performs the stacking operations according to production instructions.There are problems such as large number of workers, high labor intensity, poor working environment, high safety risk and poor continuous stability of work. The automatic stacking production operation system consists of precise positioning system, ground correction device, field scanning system, video monitoring system, machine automatic control system.

During operation, the driver only needs to sit in front of 4 computer screens to implement remote intelligent control, which can realize automatic lifting, palletizing, pitching and rotation of the stacker. The stacker replaces "manual operation" with "intelligent control". The operation of one driver per shift to two stackers has been changed from the original two drivers per shift to one stacker. It not only improves the operation efficiency and safety management and control level of the stacker, but also improves the working environment of the driver. In special cases, the driver could switch manual control of the stacker. The compatibility, security and integrity of the automatic stacking production operation system have reached a higher level.

3.3 Deep application of other new management and control technologies

In order to solve the belt conveyor system problems of deviation and blocking, the belt deviation correction device and sweeper device have been modified. The new belt deviation correction device can automatically adjust belt position through the intelligent control, which effectively solves the mechanical damage accident due to the personnel subjective factors. Th automatic weight compensation and safety warning device is installed on the sweeper device, which realizes the automatic adjustment of the sweeper device's tightness and knife head wears automatic alarm. The manual daily inspection workload is reduced. The cleaning workload is reduced by 30%.

The safety protection device is a key device to ensure the safe operation of the belt conveyor system. Through optimizing the installation position of the blocking device and adding a thermal imaging camera, the safety protection device has been upgraded. The high false alarm rate of traditional blocking switch leads to frequent shutdown of the system, which seriously affects the efficiency and safe operation of the system. The external "mousetrap" type blocking switch is adopted, which can greatly improve the accuracy of alarm. The false alarm rate is zero.

The fire protection device at the driving part of the belt conveyor system is an important part. The thermal imaging cameras are installed on the drums and drive motors.Their operating temperature and status are displayed in real time, as shown in Figure 3. The early detection and early warning of the system failures can be realized. The expansion of failures can be avoided and the failure rate of the system can be reduced.



Fig. 3 In-depth application of new technologies

4. Safety optimization of supervision operations

Through using information technology, the various operation approval processes are standardized and the scene of on-site maintenance are controlled in real time. First, the maintenance dispatch and maintenance process will be tracked in the whole process. The relevant maintenance status will be associated. The maintenance operation is under closed-loop control. Second, focus on the control of hot work, hoisting, climbing and other dangerous operations. All processes are approved online and the circulation time is saved by more than 90% compared with the traditional paper process. The preparation before operation shall be done well to prevent illegal operation. Third, the core control role of the central control room needs to be brought into full play to ensure timely and effective information upload and release. The misoperation of the system caused by information asymmetry can be avoided.

The concept of "Hidden danger is accident" has been firmly established. The work has been indexed, specified and supervised to achieve the purpose of "Everyone manages safety, Everyone wants safety". The process of operation activities can be checked and the behavior of personnel can be controlled.

5. Conclusion

The scale of China's ore import is very large. Based on the general trend of large-scale ships, intelligent port production and strict environmental protection supervision, The production mode of ore handling, storage and transportation will continue to change. The new production system with outstanding environmental protection performance and intelligent safety supervision means has become the mainstream in the future. The belt conveyor system with large transportation volume is among them, which will still be the indispensable main equipment for bulk cargo production for a long time.

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