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Research on Operation Breakdown and Intelligent Inspection Technology of Conveying Equipment in Coal Terminal

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Abstract. Conveying equipment is an important equipment for conveying bulk cargo materials in coal terminals, which has the characteristics of large volume, high efficiency, and low operating cost. The fault detection and disposal of conveying equipment during operation is an important guarantee for the normal operation of the terminal. This paper focuses on analyzing the types of faults such as conveyor belt deviation, slippage, longitudinal tearing, overload, spreading and stacking, abnormal temperature, and fire, puts forward the functional requirements of the safety intelligent inspection system of conveying equipment, and studies the composition of the safety intelligent inspection system of conveying equipment and the functions of its subsystems. The intelligent inspection system has been applied to the coal transportation system of Yulong Petrochemical Terminal to realize all-weather unmanned inspection operations during coal transportation and production operations, improve the safety management of coal transportation equipment, and strongly support the construction of intelligent port and safe port.

Keywords. intelligent port, safe port, conveying equipment, conveyor belt

1. Introduction

As one of the important equipment in coal terminals, conveying equipment has the advantages of large capacity, high efficiency and low cost [1]. It is the "lifeline" of bulk cargo transportation at the terminal and is widely used. Especially in recent years, conveying equipment has developed in the direction of "long distance, high belt speed, large capacity, and high power", and the conveying equipment used in coal terminals has also shown a trend of increasing year by year.

Fault detection of conveying equipment during operation is an important process in the normal production operation. At present, the safety management mode of conveying equipment is based on the spot inspection and regular inspection, and it still stays on the traditional inspection mode of the on-site, shut down, and offline. In actual production, due to the shortcomings of long distance, multiple monitoring locations, and harsh working environment of the conveying equipment, the personnel cannot find the problem

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in time. If the failure is not detected in time after the failure, it will affect the safe operation of the conveying equipment and even cause a major accident.

The conveying equipment is mainly composed of rack structure, rollers, tape, drive rollers, motors, and other parts. During long-term operation, the conveying equipment will be damaged. The most common are roller failure, conveyor belt tearing, abnormal temperature rise of equipment, equipment stacking, and other problems. These problems will affect the normal operation of the belt conveyor, which will produce more serious vibration or noise, and even cause the local temperature of the tape to be too high and cause combustion, which can cause coal mine accidents [2-5]. In September 2020, a conveyor belt fire accident occurred at Songzao Coal Mine in Chongqing, resulting in 16 deaths and 42 injuries [6]. In June 2022, a worker was accidentally involved in the conveyor belt while cleaning up the leaking material of the conveyor equipment in Fangchenggang, resulting in one death.

2. Analysis of Failure Types of Conveying Equipment

During the operation of the conveying equipment, accidents such as damage to the roller, fracture of the conveyor belt, longitudinal tearing, deviation, and spilling are prone to occur, resulting in equipment failure. The main types of failures of conveying equipment are the following:

(1) Conveyor belt deviation

Conveyor belt deviation refers to the deviation of the center line of the conveyor belt caused by incorrect feeding and aging of the conveyor belt during the operation of the conveyor equipment. It is a common fault in the material conveying process.Deviation the conveyor belt will cause the conveying equipment to sprinkle materials locally or even across the board, resulting in serious production accidents.

(2) Conveyor belt slippage

Conveyor belt slippage means that the conveyor belt cannot run in sync with the drive drum or the conveyor belt does not turn. Slippage in production should be eliminated in time. Otherwise, it will damage the conveyor belt, cause the belt to break and the drum's temperature to rise, and even produce smoke and cause a fire.

(3) Longitudinal tearing and broken belt of conveyor belt

When the conveying equipment is working, the conveyor belt is torn due to excessive tension or aging of the interface, and sharp protrusions or edges and corners in the material pierce the conveyor belt, which generally occurs mainly at the tail loading point.

(4) Conveyor belt overload

When the conveyor belt is overloaded, the current of the active roller drive motor will rise, and if it exceeds a certain period of time, the drive motor will be burned out.

(5) Sprinkling occurs in the conveying equipment

When the conveying equipment is severely overloaded, deviated, or started due to the rebound of the concave section, etc., the sprinkling at the reprinting point is mainly in the chute, guide trough, and other links.

(6) Stacking of conveying equipment

Stacking is a failure caused by debris clogging the nose during material transportation, which directly affects the normal operation of production.

(7) Abnormal temperature and fire

In production, the slippage of the roller of the conveying equipment will cause the temperature of the roller and the bearing to rise, which can easily cause the material or conveyor belt to catch fire, and a fire will occur.

3. Functional Requirements of an Intelligent Inspection System for Conveying Equipment

The functional requirements of an intelligent inspection system for conveying equipment mainly include monitoring and early warning, formulation of inspection plan, remote operation control, and presentation of inspection report. The specific requirements are as follows.

(1) Monitoring and early warning

The safety intelligent inspection system has a real-time monitoring and early warning interface, supports the status query of intelligent inspection equipment, and provides early warning and warning before equipment failure based on the inspection information.

(2) Formulation of inspection plan

The intelligent inspection system has a planning function, which adjusts inspection tasks, formulates inspection plans, and issues inspection tasks according to actual monitoring needs.

(3) Remote operation control

The intelligent inspection system has a remote operation and control function, which supports managers to remotely control the intelligent inspection robot to any allowed place according to the actual inspection needs, and remotely control and inspect specific equipment.

(4) Presentation of inspection report

The intelligent inspection system has the function of presenting data reports, which can automatically generate equipment defect reports. It supports the display of historical inspection data statistical analysis results, picture storage, etc. through lists, calendars, and other diversified forms.

4. The Research on the Safety Intelligent Inspection System of Conveying Equipment

The intelligent inspection system of conveying equipment consists of intelligent inspection robots, wireless temperature and vibration measurement systems, visual inspection systems, wireless communication systems, parking devices, dedicated tracks, upper computer workstations, and other equipment, as shown in Figure 1.

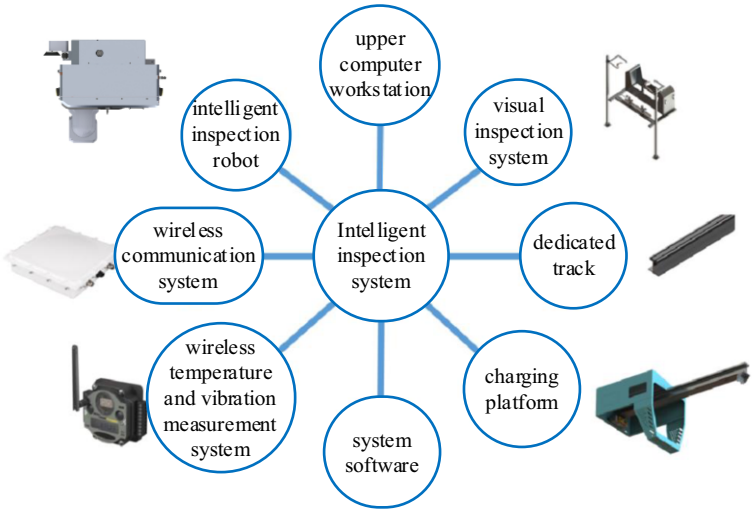

Figure 1. Schematic diagram of intelligent inspection system of conveying equipment

4.1. Intelligent Inspection Robot

The body of the intelligent inspection robot is equipped with environmental monitoring sensors, a 360-degree gimbal (including visible light cameras and infrared thermal imagers), a two-way voice system, a sound and light alarm system, and an intelligent auxiliary unit, as shown in Figure 2. It has dust-proof, moisture-proof, anti-corrosion, and other functions to monitor the operating environment, abnormal noise of equipment, foreign objects of materials, and personnel safety, as shown in Figure 3.

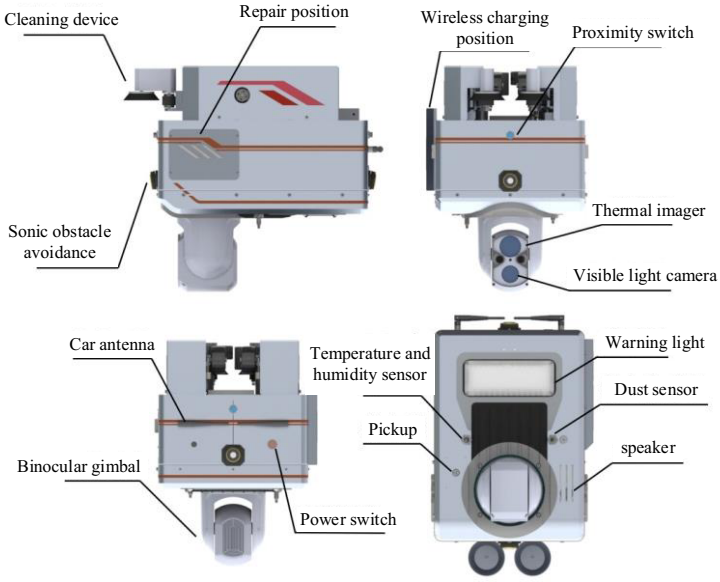

Figure 2. Intelligent inspection robot

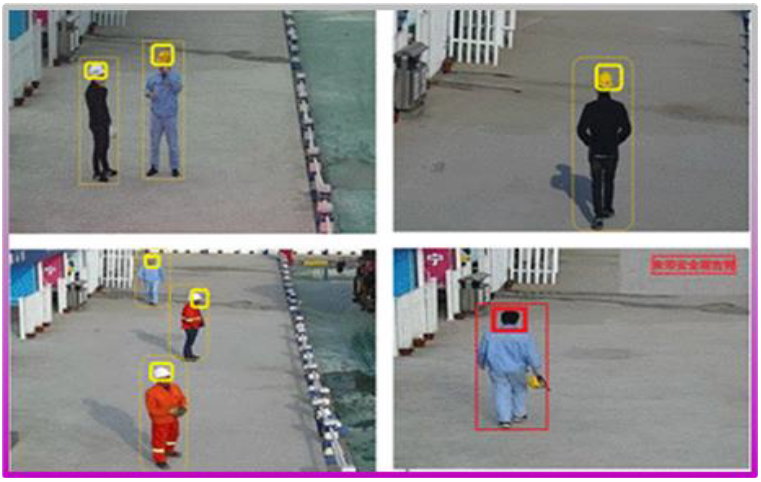

Figure 3. Personnel safety monitoring

4.2. Wireless Temperature and Vibration Measurement System

The wireless temperature and vibration measurement system can realize the temperature and vibration detection functions of key locations, and consists of three parts: temperature vibration probe, wireless temperature vibration collector, and wireless temperature vibration receiver. The wireless temperature vibration collector reads the data of the temperature vibration probe, transmits it through wireless communication, then transmits the collected data to the upper computer.

4.3. Visual Inspection System

A meter counter is placed at the edge of the conveyor belt, and the conveyor belt will drive the meter counter to rotate. With the support of the encoder and the acquisition module, the precise speed of the conveyor belt can be detected. When the detection speed is lower than the set value, it is determined that the belt is slipping. A high-speed CCD camera is used to detect the position of the laser line close to the edge of the conveyor belt. If the set position is exceeded, it is determined that there is a deviation phenomenon. Tear detection is to scan the bottom surface of the belt through the laser line in the direction of operation of the conveyor belt. When the tear detection occurs, the laser line will bend and deform in a straight line. The amplitude of the tortuous change in the straight line is determined by an algorithm to realize the tear detection of the conveyor belt, as shown in Figure 4.

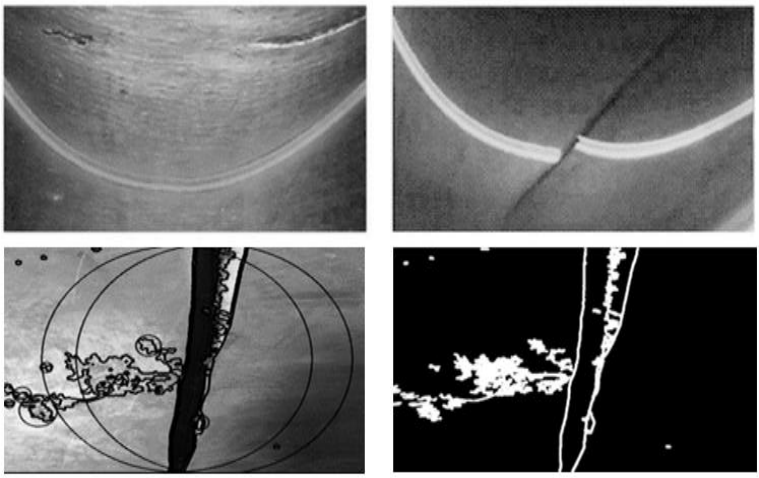

Figure 4. Conveyor belt tear detection

4.4. Wireless Communication System

The wireless communication system can use 5G dedicated network and 5.8G bridge communication methods, has a stable and reliable wireless network link and cloud link, supports video, voice, and multi-protocol data, and has good application expansion capabilities. It can realize the communication between the intelligent inspection robot and the upper computer workstation, realize the transmission of image, voice, and other data, and the transmission of motion control commands.

4.5. Parking Device

The parking device is the main parking point of the intelligent inspection robot, which is a parking device that integrates functions such as automatic charging and body cleaning. When the conveying equipment is cleaned, the intelligent inspection robot is located in the berthing device to avoid the water gun scouring the equipment. The surface of the intelligent inspection robot will accumulate ash, which will affect the normal data collection of the equipment. The parking device is equipped with clean compressed air. When the robot regularly returns to the parking device to charge or stop parking, clean compressed air can be used to clean the robot's body.

4.6. Dedicated Track

The dedicated track is the support structure of the intelligent inspection robot. It is equipped with an adjustable track hanger to ensure the coverage of the conveyor belt by the sensing equipment to achieve the safety and reliability of the inspection conveyor belt.

4.7. Upper Computer Workstation

The upper computer workstation is the terminal equipment and user interaction interface of the security intelligent inspection system, which aggregates the inspection data to the server, and calculates it through the computing server to finally present the results, as shown in Figure 5.

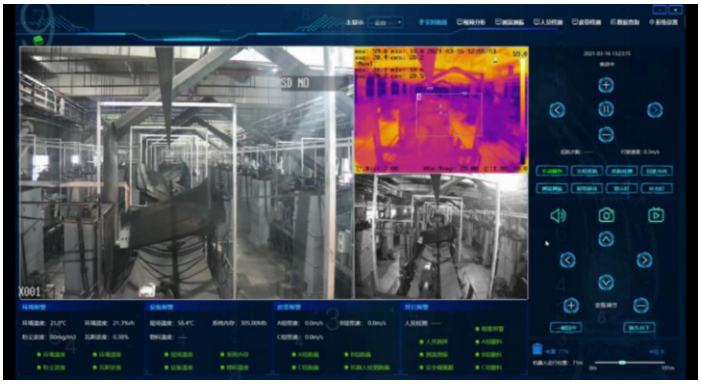

Figure 5. Real-time interface of safety intelligent inspection system workstation

5. Applications

Shandong Yulong Port Co., Ltd. has built a safety intelligent inspection system for coal terminal conveying equipment, designed one intelligent inspection robot for intelligent inspection of BC1 belt conveyor, BC2 belt conveyor, and BC3 belt conveyor, and designed one intelligent inspection robot for intelligent inspection of BC4 pipe belt conveyor, and designed two intelligent inspection robots for intelligent inspection of BC5 pipe belt conveyor to realize all-weather unmanned inspection of coal transportation production operations, as shown in Figure 6 and 7.

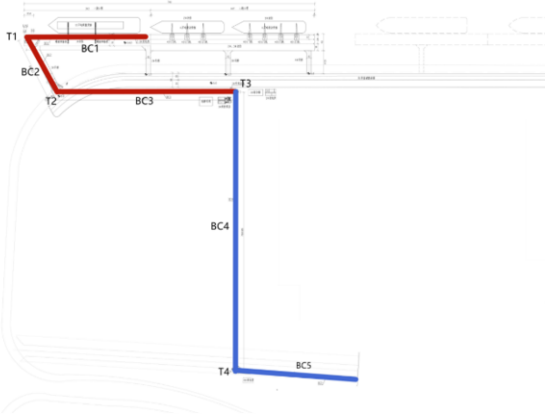

Figure 6. Coal transportation system of Yulong Petrochemical Port

Figure 7. Safety intelligent inspection system for coal terminal conveying equipment

6. Summary

With the development of safety science and technology, the traditional safety management model has been unable to adapt to the requirements of intelligent ports. The safety intelligent inspection system based on intelligent perception, intelligent identification, Internet of Things, big data, and other technologies can realize unmanned inspection of the production process of coal transportation equipment in the port, significantly reduce the labor intensity of workers, prevent and reduce the failure of transportation equipment, and improve the level of equipment safety management. It will effectively improve the intelligence, comprehensiveness, system extensibility and accuracy of fault diagnosis of coal conveying equipment safety monitoring and protection, and strongly support the construction of intelligent ports and safe ports.

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