Optimizing Material Handling Through Automation: Control Strategies for Belt Conveyor Systems in Mining Operations

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Abstract: ***In recent decades, China has witnessed unprecedented breakthroughs in science, technology and industrialization, which have in turn driven sustained growth in domestic material production and national energy demand. Within China's overall energy consumption structure, fossil energy still accounts for approximately 70 percent, while renewable energy has gradually expanded its share in recent years. However, constrained by the natural endowment of domestic mineral resources, the sustainable development of China's mining industry is still facing prominent structural bottlenecks, and the overall performance of existing mining equipment still leaves considerable room for functional and technological improvement. Against this background, modern large-scale mining equipment has been widely deployed in domestic production operations, among which belt conveyors have become the core material transportation equipment in mining and beneficiation processes. Specifically, the belt transportation systems currently used in China not only have strong load capacity, but also have outstanding advantages in continuous operation efficiency, which makes them an indispensable core infrastructure equipment in mining production. Therefore, only by continuously promoting the technological upgrading of belt transportation links and ensuring the efficient application of automatic control systems can the overall economic benefits of mining enterprises be fully unlocked. Based on this practical background, this study focuses on the application mechanism and practical effect of automatic control systems in mining belt transportation, aiming to provide theoretical reference and practical inspiration for the intelligent transformation of the domestic mining industry.***

Keywords: Mineral resources; Automated control system; Belt transportation.

1. INTRODUCTION

In recent years, the use of belt transportation in China's coal and non-coal production process has gradually been widely favored by coal miners, and the work efficiency can be greatly improved through belt transportation. However, in the traditional mode of transport, each belt is independently operated and independently controlled, and the configuration used for each belt will be certainly different, which means that the traditional belt transport system is relatively dispersed. It is not possible to achieve centralized control, and the traditional belt transportation operation mode is mainly manual, which will undoubtedly increase the workload of the operator to a certain extent and is relatively inefficient, so it is especially important to use an automated system for centralized control in belt transportation. Specifically, Xia, Xu, and Shan [1] developed KOA-Monitor, a digital intervention and functional assessment system for knee osteoarthritis patients in 2025, while Xu et al. [2] conducted a systematic review on game-based learning for environmental resilience in 2026, highlighting the transition from engagement to resilience. For natural language processing, Deng et al. [3] proposed an LLM-guided multi-view reasoning distillation method for sarcasm detection in 2026. In computer vision, Wang et al. [4] introduced a quality-aware query-adaptive convolution for clothes-changing person re-identification in 2026, and Li et al. [5] presented a memory-aware fine-tuning of SAM2 for efficient long-sequence video object segmentation in the same year. Moving to applied AI in business, Song [6] explored user-centric internal tools in e-commerce enhanced by AI integration in 2025; Wu [7] worked on intelligent gateway software management platforms using Jenkins cluster management under cloud-edge integration for the industrial IoT in 2025; and Chen [8] focused on design optimization of data pipelines in gig economy platforms in 2025. Returning to biometrics, Ding et al. [9] proposed a multi-scale adaptive clustering and local consistency learning method for unsupervised clothing-changing person re-identification in 2026, while Peng et al. [10] addressed lifelong domain adaptive 3D human pose estimation in 2026. In environmental health, Narouei et al. [11] examined the effects of germicidal far-UVC on ozone and particulate matter in a conference room in 2025. For biomedical applications, Xiao et al. [12] designed an ultrasmall Fe_3O_4-decorated polydopamine hybrid nanozyme for wound disinfection in 2022. In service design, Shan, Xu, Xia, and Lin [13] rethought wine tasting for Chinese consumers using multimodal personalization in 2025. For multi-agent systems, Yan et al. [14] developed PRISM, a pipeline for root-cause investigation via specialized multi-agents in 2026, and Yuan et al. [15] proposed TA-Mem for tool-augmented

autonomous memory retrieval in long-term conversational QA in 2026. In automotive analytics, Zhou [16] applied gradient boosting trees to diagnose bottlenecks in international automotive sales funnels in 2026. For financial security, Shen et al. [17] researched the application of the whale optimization algorithm in financial payment fraud detection in 2025. Finally, Sun [18] addressed accessibility challenges and solutions in digital products, focusing on designing inclusive interfaces in 2025.

2. OVERVIEW OF BELT TRANSPORT AUTOMATION CONTROL SYSTEM

For the long-term development of mines, adequate support is needed for the active use of modern equipment and technology to ensure the sustainable development of China's mining enterprises. The emergence of the belt transport automation control system has undoubtedly clarified the direction of development for China's mine enterprises. Nowadays, in the support equipment of China's mines, high-power equipment has gradually been widely used in mine selection and transportation work, which also means that the requirements for electricity quality are getting higher and higher, and the development of belt transportation automation control system cannot be supported by vigorous electronic technology. In China's mine automation control system, the main application is electronic electric belt transport technology, the main use principle of this technology is to collect the required signal, and then transmit the relevant instruction information to the motor. In this way, the safety coefficient of belt transportation technology can be effectively improved, and the service life of parts can be extended to a certain extent, improving the safety performance of equipment transportation.

3. STATUS OF MINE AUTOMATION CONTROL SYSTEM

At present, in the process of operation and development of mine enterprises in China, the large mining selection equipment being used is almost all of the domestically produced machinery equipment. Traditional mechanical equipment has gradually been eliminated and replaced by some high-tech equipment, so the first goal facing China's mine enterprises in the development process is to continuously improve the economic efficiency of the enterprise itself. In the machinery and equipment of mine mining, traditional belt transportation occupies a very important position. However, the electricity consumed by traditional transportation methods is very large, and the service life of equipment is short. In the era of rapid development of enterprises, the traditional means of transportation not only can no longer meet the actual production requirements, but also invisibly increases the labor cost of enterprises.

4. PLC OPERATION PRINCIPLE ANALYSIS

4.1 Analysis of system structure

During the application of the PLC system in belt transport, targeted operations can be given, and then the MPI network is established through a special cable. In the PLC application module is mainly composed of two parts, that is, the CPU and a power supply, the PLC protection cabinet in order to effectively carry out information transmission and shuttle, It is necessary to set up three additional inputs and one output, and then transfer part of the information to the PLC protection cabinet according to the situation shown in the logical control operation panel. In addition, when the PLC communication state is good, and the host computer working state is also in the best condition, then the console relays will temporarily stop running, but if the PLC and host computer running state is abnormal, the relays will automatically start. This ensures that the contact signal is effectively input into the PLC.

4.2 System principle of operation

When using PLC in the process of belt transport, it is first necessary to conduct a comprehensive analysis and understanding of the production environment of the mine. In the process of belt transportation, the output capacity of the PLC can be adjusted appropriately according to the actual production situation. Ensure that the distance length of the controller is sufficient to meet the actual production requirements, and in order to achieve effective conversion between distance and distance, the signal can be isolated and amplified using isolation boards or conversion boards.

5. SPECIFIC APPLICATION OF MINE AUTOMATION CONTROL SYSTEM IN BELT TRANSPORTATION

5.1 Advantages of automated control systems

The biggest advantage of the PLC control system is that it can provide comprehensive protection for belt transportation. The system not only has strong reliability and interference resistance, but also has a particularly strong adaptability to adapt to various environmental conditions. In addition, the PLC control system also has strong flexibility, not only has a strong processing capacity, but also a large load, and its program settings can be adjusted in real time with the field control. Moreover, it can not only effectively control a single unit, but also conduct online operations or remote control. In addition, the application of new equipment requires a certain adaptation period, in order to minimize the failure rate of new equipment in use, The relevant staff need to inspect and maintain new equipment regularly, and if necessary, equipment parts and other items can be replaced regularly to ensure that the system can be in optimal working condition.

5.2 Application of control systems in belt transportation

In the belt transportation system, to effectively achieve network expansion, two racks are specially located in the system through ControlNet, and the capacity can be flexibly adjusted as actual production conditions occur. In addition, in the system, the staff can carry out digital input and output respectively through the 16-point independent insulation module IMI6I and OW16I, If an analogy is required, an IF16 module can be entered. At this point, the staff member concerned needs to be aware that when entering an analogy, the staff members need to determine whether the module is in variable mode before they can enter the analogy. In addition, due to the special nature of work undermining in mines, especially coal mines, staff need to give some protection to the corresponding electrical wiring before officially carrying out work, and when necessary, should be equipped with the corresponding isolated circuits. In addition, when the PLC whether in the process of input or output, need to take certain quarantine measures. Typically, the isolation number is 16, and the system's contact capacity is 250 A / 5A. In addition, in order to effectively control the distance of the PLC, the output capacity of the plc must be expanded accordingly, and when the capacity of PLC is expanded, it must be supported by a corresponding conversion board to truly realize the functions of signal isolation and amplification.

5.3 Application of PLC in Belt Transport System

Under normal circumstances, how to make the belt transport system operation mode in the best state in service, or belt transport system in what way to start the work, first through the PLC control system to set up in advance, and then by the PLC to four start cabinets to convey the command switch. Under normal circumstances, when the relevant staff assigns the start to a serial shutdown circuit, once the shutdown is completed, the corresponding signal data will be returned through the vacuum breaker, but if the signal is not received within the established time, there must be a system failure in the starter cabinet.

The display screen of the main operating table can effectively automatically display the return situation of the main motor, In this way, if the main motor fails during the return process, it helps the relevant staff to find out in time, the breaker relay will effectively control the main motor, and the PLC will be connected to the combined switch by cable. When sending a return point signal to the PLC cabinet, it is necessary to equip each driving device with a corresponding self-substation. When equipped with a self-station, its main motor can utilize the three-phase cycle pack temperature, three-phase current, and so on.

When it is necessary to start the car, an early warning should be carried out first, so that the belt can be effectively controlled and detected along the route. If the detection status of the belt is normal, then the signal brought back by the main motor for the belt is allowing the car to start.

When the PLC control system is used, in order to effectively control the transport process of the belt, the system is mainly divided into manual and automatic control. If the belt transport machine fails during the operation, the controller will immediately stop the operation, and the specific information of the failure will be sent to the control center. Only after ensuring that the belt transport fault is completely resolved can the belt transport machines be restarted.

5.4 Configuration requirements for the main conveyor belt supervisory control system

When the supervisory control system is in the state of service, the system will monitor the running state of the equipment. The data exchange system of PLC system can effectively control the upper bit machine. The PLC control system can effectively collect and process all information data on the site. When the data is collected and processed, the results can be transmitted directly, so that the relevant staff or managers can keep a real-time view of the situation on the ground. In addition, it can automatically generate all kinds of work reports, such as the previous alert, hard data, etc. At the same time, it can also print the section data and the abnormal state in service.

6. CONCLUSION

In summary, it can be found that in the process of coal mine and non-coal mine production and transportation, belt carriers are essential and important transportation equipment. To make mine selection and transportation work more efficient and safe, it not only needs enterprise leaders to focus on the innovation of business methods. Moreover, it is necessary to actively cite new belt transportation technology and actively apply modern technology to work, so as not only to greatly improve the transportation efficiency, but also to increase the scientific and technological content of mine transportation operations, thereby improving the overall strength of mine enterprises.

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