Informationization and Big Data Technology in Management and Maintenance of Mining Equipment in Large Open Pit Mines

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Abstract. In the rapid economic development today, accelerating coal mining to ensure energy supply is an important guarantee for the healthy and stable development of the economy. Compared with underground mining, open-pit coal mine is of relatively low technical difficulty and mining cost. Through high-efficient, environment-friendly and energy-saving green mining of large complete sets of equipment, open-pit coal resources can be fully utilized. In order to improve the efficiency of open-pit coal mining, this paper studies the application of information technology in the management and maintenance of mining equipment in large open-pit mines. This paper builds an intelligent control model based on the study on strengthening the intellectualization of the complete set of semi-continuous mining equipment of 10,000-ton open-pit coal mine, so as to improve the operation efficiency and safety of the semi-continuous mining equipment of 10,000-ton open-pit coal mine through automatic detection, monitoring, protection and control of the mining equipment. The results show that the equipment management efficiency is improved by 42.12% after using the intelligent control model. This is conducive to improving the management efficiency and maintenance of mining equipment.

Keywords: Semi-continuous Mining Complete Equipment, Intelligent Control, Large Open-pit Mine, Management Efficiency

1. Introduction

Compared with similar coal mine products in foreign countries at present, there are still some deficiencies in the intelligent management of equipment control system of open-pit mines with a capacity of more than 10 million tons, resulting in the inability of mining complete sets of control
equipment products to give full play to their output continuous mining control capacity to the maximum extent \cite{1,2}. Strengthen the automatic safety detection, monitoring, protection and safety control management system for open-pit mines with a capacity of more than 10 million tons, so as to gradually form a further intelligent safety detection and control \cite{3-4}.

Moreno, Eduardo proposed a new linear model for inventory modeling in open pit mines. Moreno, Eduardo compares how several assumptions affect the quality and processability of open pit inventory solutions. These models include hybrid requirements without unrealistic assumptions. Experiments show that the model proposed by Moreno and Eduardo is easy to deal with and has better effect \cite{5}. Meeting production targets for ore quantity and quality is critical to the success of mining operations. Uncertainty about local ratings can lead to both deviation from production targets and general fiscal deficits. Gilani, seyed-omid proposed a new stochastic optimization algorithm based on ant colony algorithm for the comprehensive simulation of geological uncertainty of ore bodies. In order to improve the initial solution generated by deterministic ant colony algorithm, Gilani, seyed-omid developed two different strategies. The application of the Sungun copper mine in northwestern Iran has shown that the random method can create a single schedule and increase project value \cite{6}. Mining activities, especially open-pit mines, have a significant impact on the earth's surface. Therefore, it is an open challenge for the earth science community to find a fast, accurate, and low-cost way to monitor changes in this manmade environment over the years. Xiang, Jie chose a case study located northeast of Beijing to assess geomorphologic changes associated with mining activities. In 2014 and 2016, a drone collected two sets of high-resolution images. The motion structure photogrammetry technology is used to generate a high-resolution digital elevation model \cite{7}.

At present, China urgently needs to develop a complete set of automatic detection, monitoring, protection and control system for open-pit mining equipment \cite{8}. Combining informatization and big data technology, this paper tries to develop a set of simulation algorithm, and has achieved good results, in order to provide technical advice for the intelligent maintenance and management of the new generation of large-scale industrial equipment, and to guarantee the reliability, security and efficiency of the system operation \cite{9,10}.

2. Proposed Method

2.1. Composition of Surface Mining Equipment

The main function of the complete set of equipment for semi-continuous mining in the 10,000-ton open-pit mine is to use the self-moving crushing and digging station mining machine as the operating core to assist, and to form a complete set of continuous mining operation line with the combination of a single-bucket excavator, a loader and a belt material conveyor. Scattered in large open-air coal mining process, single bucket excavator station to complete the raw coal GeKuang scattered mining of coal loading and unloading operation, move all raw coal conveying ore bodies to the raw coal crusher station, since the translation type raw coal crusher station will be broken after all raw coal ore body, the discharge power transfer machine with conveyor device in continue to belt type raw coal transport planes, realize the coal mine coal scattered mining, conveying.

Thousands of large-scale open-pit coal mine equipment set semi-continuous mining mining equipment, especially especially large broken workstations and reproduced machine equipment, work
in a variety of undulating slope, and occasionally turn climbing movement happens, such as equipment often cannot keep under the working condition of the tilting, and often have a climbing, turning condition.

2.2. Intelligent Control Algorithm

A Source is an object that allows a created entity to fire an event at a specified rate through a specified arrival mode. There is an output buffer in the Source. When the entity must wait due to some reason or mode of the simulation system, the entity can wait before passing through the Source node and then arrive at the specified service station through the node.

Set the minimum value $a$, the maximum frequency $m$ and the maximum frequency $b$, and the distribution density is as follows:

$$f(x) = \begin{cases} \frac{2(x-a)}{(m-a)(b-a)} & \text{if } a \leq x \leq b \\ \frac{2(b-x)}{(b-m)(b-a)} & \text{if } m \leq x \leq b \end{cases}$$

(1)

Uniform distribution is widely used in situations where the probability of possible continuous events is roughly equal or equal, and all events within an interval are equally likely to occur:

$$f(x) = \begin{cases} \frac{1}{b-a} & \text{if } a < x < b \\ 0 & \text{else} \end{cases}$$

(2)

3. Experiments

3.1. Experimental Background

As soon as possible, the company can independently develop and develop a set of internationally advanced and high-level complete control equipment, which can effectively save a large amount of mineral fuel, greatly consume human resources and break the bottleneck of domestic mining technology. Development of advanced surface mining technology can make at present, China's large open-air mine mining technology and the comprehensive development and application level of the complete set of process equipment into Chinese modern world's advanced level as soon as possible, no matter in the industrial technology innovation concept, or the national economy, the natural environment and social benefit is very important social reality significance.

3.2. Experimental Design

S7-400 is used as the control core in the automatic control of the semi-continuous mining system of 10,000-ton open-pit coal mine, and a monitoring and control network based on industrial Ethernet is built on site to complete the monitoring and control of the semi-continuous mining equipment of 10,000-ton open-pit coal mine. Taking the open-pit mine A as an example, the positions of the self-moving crushing station and the loading machine were located by adding GPS and UWB
components to the self-moving crushing station and the loading machine, so as to realize the control of the automatic docking between the self-moving crushing station and the loading machine. When the shovel needs to move in a small area of the working face, the self-moving crushing station and the self-moving transfer machine need to be adjusted manually. Some simulation results are shown in Table 1.

**Table 1. Simulation results**

| Calculate indicators | The index code | Double-tooth roll crusher | Hammer roller crusher | Wheel soft rock crusher |
|-----------------------|----------------|---------------------------|-----------------------|------------------------|
| Ability to lift        | X1             | 0.1114                    | 0.0000                | 0.0506                 |
| Sets the capacity      | X2             | -0.1304                   | -0.1304               | 0.0000                 |
| Response rate          | X3             | -0.1458                   | -0.1458               | 0.0000                 |
| Range of discharge size| X4             | 1.0000                    | 0.5153                | -0.0316                |
| Real tempo             | X5             | 0.0000                    | -0.4210               | -0.0185                |

4. Discussion

4.1. Analysis of Management and Maintenance of Mining Equipment in Large Open Pit Mines Based on Informatization and Big Data Technology

As shown in Figure 1, compared with the mining equipment management of mine A before, the equipment management efficiency has been improved by 42.12% after using the intelligent control model, and the use efficiency has been improved under the comparison of various indicators. In the operation of the intelligent control model, through the translation type crushing station of perception and attitude, automatically adjust the stability of the move will help ensure the type crushing station, through on the move since the fragmentized site with horizontal and vertical position sensor to move to the type of crushing plant operation at condition monitoring, and mounted on it to move to the type of wind speed sensor when crushing station wind speed profile of field detection, and through the calculation to the fragmentized station capsized calculated risk, And according to the horizontal and vertical state feedback and wind speeds to adjust move since the fragmentized standing posture (with the rotation of the upper fuselage and the adjustment of the discharge arm), is used to adjust the translation type crushing plant's center of gravity, at the same time to move the fragmentized standing posture, the danger of high-risk attitude when working monitoring control and security since the move type of safe and efficient operation of the crushing station.
Since moving type composite crusher and small reproduced machine in the process of running rely mainly on two different crawler movement speed difference can turn speed, in what is now the translation type comprehensive crushing machinery and small transfer machine two track speed regulation control, domestic and foreign large-scale since moving type comprehensive crushing machinery and small transfer machine speed regulation is widely used on the two tracks completely is manual operation mode of speed control, rely on artificial control of motor speed operation can not do the utmost to ensure realization of mechanical power and match, the two tracks on the speed and mechanical engine matching work can't under the best operation effect simultaneously. The track speed of the complete processing equipment for semi-continuous processing and mining in open-pit mines of more than 10 million tons is generally low, aiming at three typical cases of track turning and backing (track in-place braking turning: one track in place braking, the other track in advance; Fast sliding displacement turning: one goes back through the track braking, the other goes forward through the track braking; Large span radius caterpillar turn: brake slow moving backward through a track, through another track brake fast forward backward), can adopt the method of track intelligent speed controller to track speed regulation and control in real time dynamic combination matching, achieve rapid increase efficiency, reduce energy consumption of equipment application purpose. Move in the special type crusher station and automatic transfer machine dedicated track base station intelligent motion control and operation on the dynamic intelligent matching the special translation type crusher station and automatic transfer machine dedicated track intelligent running speed regulating relations in-depth study, using the algorithm of artificial intelligence technology to intelligent two motor speed adjustment and dynamic matching to achieve minimal power consumption and weight control is used to effectively complete motor turning speed operation, improve the automatic transfer type crusher stations and special reproduced machine crawler movement speed stability and reduce the movement of energy consumption.

As shown in Figure 2, after the introduction of intelligent control simulation system, the cost loss rate of mining equipment was reduced by 23.12%. Reduced crushing station investment by 38%; The parallel shift setting among all modules of the crushing station is realized, so that the shift setting time
of the crushing station is reduced to less than 7d, and the actual shift setting time is only about 70h (shift setting is only for day shift operation). It ensures the stable and reliable operation of the equipment, and the completion rate of coal mining crushing station is more than 95%. It can be seen that the efficiency can be improved through the intelligent implementation of this complete set of equipment. The economic benefit of each set of equipment is increased by more than 100 million yuan per year. The main calculation basis is as follows: the use of automatic and accurate docking technology can significantly save the docking time and improve the total working efficiency by more than 20; And the equipment can work at night. Only by increasing the working efficiency by 20%, the production line with an annual output of 10 million tons of coal can extract an additional 2 million tons of coal. Developed equipment important working parameter of automatic measurement and sensing technology, and implement open interconnected the working state of complete sets of equipment, complete sets of equipment information integration with depth of mining, make large equipment wisdom, so as to improve the level of equipment manufacturing enterprise, the application level and management level, solve the production safety, training equipment of the tube, use, such as raising, protection, and other issues.

![Figure 2. Variation of cost loss rate under intelligent control](image)

4.2. Suggestions on the Management and Maintenance of Mining Equipment in Large Open Pit Mines Based on Informatization and Big Data Technology

In order to achieve the union of open-pit mines mining equipment operating production data theme, particle size, more demand, efficient, fast display, research, and query retrieval, need to be united mining in open-pit mine, on the basis of complete sets of equipment production database operation, building a data warehouse with data warehouse technology, and further use of OLAP and other conventional analysis methods, the deep analysis of the data. We plan to realize several factors such as human operation, environmental parameters, system design parameters and system failure in environmental data of production environment of open-pit mining equipment.
It is proposed to use data warehouse technology to monitor the safety of production environment. Impact of project schedule. Among them, the information related to human operation mainly includes the information of workers' operation in different operating environments. The information related to environmental factors mainly includes soil pressure, flow, temperature, stroke, etc. System design parameters related information mainly includes PLC, inverter speed and other related parameters; The system failure factor mainly records the system problem or the failure of the corresponding component information.

Online learning can be viewed as an optimization approach. With the continuous access to the data, the off-line optimal solution is approached step by step. Combined with the establishment of intelligent perception and expert system, the online learning model can well achieve the effect of site prediction and site simulation, and the obtained model can be used to train new operators.

5. Conclusions

In this paper, the concept of intelligent control algorithm and open-pit mine is firstly sorted out. Then, considering the requirements of production system, material conditions, equipment conditions and social factors, an intelligent control simulation model is established in order to improve the efficiency of surface mining equipment management and maintenance. Then, according to the optimal index system established with the aim of maximizing the benefits of semi-continuous process in open-pit mine, the alternatives are evaluated. The results show that the mining efficiency and management efficiency have been improved significantly.

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