Research on Open Mining Intelligent Equipment Based on Internet

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Abstract. Based on the establishment of mines, the use of advanced industrial Internet technology, based on the solid model and block model, using 3DMine smart equipment software to study the intelligent collection equipment of open pit mines, through the intelligent research of equipment, research and development It has developed advanced quota intelligent equipment, including intelligent sorting system and intelligent collection device system, etc., and discussed the influence and application of different intelligent equipment in the state of open pit mine. The preliminary design provides a technical plan and decision basis for smart equipment.

1. Introduction

Open-pit mines' smart equipment accounts for a large proportion of modern smart equipment processes, and their field optimization is an important part of open-pit smart equipment. In the field of open-pit smart equipment, especially the 10 million-ton mine area, achieving the best intelligent equipment in open-pit mines has always been the goal pursued by smart equipment workers, and it is also an important means to reduce costs to obtain the best economic benefits and improve smart equipment competitiveness. Enterprises in the market. The traditional determination of the field of open-pit smart equipment intelligent equipment fully considers the impact of economic and technical factors on equipment optimization, resulting in the ideal eventually having certain advantages in the field of intelligent equipment. With the development of computer technology, researchers of smart equipment intelligent coal smart equipment equipment have proposed the method of using computer circle definition. Commonly used methods include: 2D dynamic programming and 3D graph theory, floating cone method, 3D dynamic programming, network maximum flow method, positive cone deletion method, etc. Among them, the floating cone method and LG graph theory method are the most widely used. These computer optimization methods are all based on the arrogance theory to achieve intelligent equipment to improve labor productivity and speed up the collection speed.

Based on the use of intelligent equipment in the smart equipment area, this article establishes a three-dimensional visualization model, estimates and evaluates the reserves of the smart equipment area, and provides a reliable basis for the company's decision-making based on the current smart equipment situation. Refer to the smart equipment manual and engineering experience, determine reasonable open-pit smart equipment parameters, and use 3D intelligent equipment to connect and control through software, and design the open-air development route for 3DMine, which has important and far-reaching significance for the smart equipment industry. Make scientific plans, develop reasonably, realize the mines with maximum economic benefits, and build smarter equipment.
2. The core architecture of smart equipment

2.1. The connotation of smart equipment
In the smart equipment of mineral deposits, the smart equipment equipment process is characterized by the digitization of the smart equipment equipment environment, the intelligence of the smart equipment equipment, the remote control of the production process, the information transmission network and the operation management information. Smart equipment. The core connotation of intelligent equipment is mainly digitalization, mechanization and informationization. Digitalization is the basis of intelligent equipment. Without digitization, there is no smart equipment. By establishing a digital model of deposit geological information and Open-pit mines' equipment smart equipment equipment engineering environment, a good digital platform for basic information of intelligent equipment has been formed, and basic data of intelligent equipment information flow has been established. At the same time, the construction of basic information digital platform is also equipment management system, production planning organization, scheduling system optimization, personnel positioning system, equipment management system, equipment management system, equipment management system, equipment management system, equipment management system, equipment maintenance system, system The basic data platform for the subsequent design, development and system operation of six major systems: maintenance system, system maintenance system, system maintenance system, system maintenance system, system maintenance system, system maintenance system, system maintenance system, and system maintenance system. And security.

Mechanization is a means of intelligent equipment. The development of smart equipment equipment technology is essentially the development of smart equipment equipment technology. The mechanization of intelligent equipment is different from traditional equipment. It is not only the mechanization of large-scale smart equipment of advanced smart equipment research and development equipment using mechanical equipment, but also the mechanization of intelligent equipment for information control and intelligent operation. It is a key link of China's State Administration of Safety Supervision and Administration of "mechanical substitution and automation". Reduce ". With the development of remote-control technology and remote-control technology, smart equipment equipment equipment in smart equipment equipment engineering should be changed from smart local machines to smart control of the entire process chain. Smart equipment must be integrated with remote control of the production process in order to form smart equipment equipment research and development equipment. The intelligent platform can realize single-link remote mechanized operation and promote efficient production and intrinsic safety of the mine. Informatization is the guarantee of intelligent equipment. Informatization is based on such as network switches and 4G communication signals Information transmission system. It uses the Internet of Things, office information system, automatic data processing system and other means to realize the network of information flow of real intelligent equipment through various sensors and service terminals. The visualization of the production process and intelligent production management form a connection the intelligent equipment information system of people, people, intelligent equipment, and intelligent equipment and intelligent equipment. The intelligent equipment dynamically and dynamically controls the entire process of intelligent equipment safety production and operation in real time, thereby ensuring the ecological stability and sustainable economic growth of intelligent equipment. [1].

2.2. Intelligent equipment core architecture model
The intelligent construction of intelligent equipment requires the overall structure of "three platforms and one system", including basic information digital platform, intelligent equipment platform, production information management control platform and communication network transmission system. It also needs to integrate intelligent equipment method and process design to optimize smart equipment equipment process parameters, thereby forming a closed-loop intelligent equipment architecture model, as shown in Figure 1. Using this model architecture as a blueprint, the digital production information of
intelligent equipment realizes the mechanization of the production process, automation of the production process, intelligent production management and high-speed information transmission [2].

Figure 1. Intelligent smart equipment architecture model

3. Smart device selection method and mathematical model

3.1. Smart device selection principles

3.1.1. Productivity. Productivity refers to the productivity of equipment, generally expressed in terms of equipment output per unit time. When selecting equipment, according to the needs of production, the production capacity of the equipment must match the system. The production link of a certain equipment should not be less than the capacity of the system, limit the performance of the system, and should not have excessive surplus. Necessarily increase the investment cost of equipment.

3.1.2. Reliability. Reliability refers to precision, accuracy retention, component durability, safety reliability, etc., when selecting the model, the equipment must have sufficient reliability, and it should be able to operate stably under normal use and maintenance conditions, the chance of sudden failure in work is small.

3.1.3. Security. Safety refers to the guaranteed performance of the equipment for production safety, such as whether an overload or fault automatic protection device is installed. The protection level of the equipment should meet the requirements of the safety regulations, or after taking measures according to the regulations, it should be able to meet the requirements of the current safety regulations.

3.1.4. Economical. The economic requirements for equipment selection include: low initial investment, high production efficiency, long durability, low energy consumption and raw material consumption, low maintenance and management costs, and labour saving. In the selection of equipment, it is mainly measured by the life cycle and cost of the equipment, including the sum of equipment purchase costs, operation and maintenance costs, maintenance costs, and equipment renewal costs, etc., rather than just one of the equipment in use. The cost of the stage is based on the level.

3.1.5. Environmental protection. Refers to the pollution of the environment by the noise, emissions and other harmful substances of the equipment should meet the requirements of the national environmental protection regulations, and the lower the pollution level, the better.

3.2. Mathematical model of equipment selection

According to the principle of equipment selection, when selecting large-scale equipment, it is generally required to use the same type of mechanical equipment for the same operation as much as possible. It is
now assumed that $x_j$ is the number of the $j$-th type of equipment required to select a certain type of equipment $B$ ($j = 1, 2, \ldots, n$, $n$ are the number of equipment models available for selection).

### 3.2.1. Objective function.
Taking the minimum annual cost as the goal, the general expression of this objective function is:

$$
\min \frac{Z}{j} = \left[ a_j \left(\frac{i(1+i)^n}{(1+i)^n-1} + b_j \right) \right] x_j + \left( f_{x_j} + f_{x_j} \right)
$$

In the formula: $a_j$ represents the single purchase cost of $j$ type equipment; $b_j$ represents the annual maintenance cost of $j$ type equipment; $n$ represents the service life of $j$-type equipment; $f_{x_j}$ represents the additional annual investment cost of $j$-type equipment; $f_{x_j}$ represents the $j$-type equipment The additional annual maintenance cost of the equipment; $i$ represents the annual interest rate.

### 3.2.2. Constraints.
It is divided into production constraints and financial constraints, which is:

$$
B_j x_j \geq M \tag{2}
$$

$$
\alpha_j x_j + f_{x_j} \leq I_{\text{max}} \tag{3}
$$

In the formula: $B_j$ represents the production capacity of the $j$ type equipment; $M$ represents the smart equipment volume of each shift. $f_{x_j}$ represents the relevant investment cost of the equipment; $I_{\text{max}}$ represents the initial investment limit. Based on the above three formulas, the mathematical model for the optimal configuration of smart equipment equipment selection is:

$$
\min \frac{Z}{j} = \left[ a_j \left(\frac{i(1+i)^n}{(1+i)^n-1} + b_j \right) \right] x_j + \left( f_{x_j} + f_{x_j} \right)
$$

s.t.

$$
B_j x_j \geq M \tag{4}
$$

$$
\alpha_j x_j + f_{x_j} \leq I_{\text{max}}
$$

### 4. Development of open-pit smart equipment intelligent blasting system

#### 4.1. Overall structure
Using the Internet of Things and information technology as the link, build an intelligent open-pit mine blasting construction system based on the Internet. as shown in picture 2.

![Figure 2. IoT architecture of intelligent blasting system](image-url)
The application layer mainly includes the blasting design software and monitoring software required by management and technical personnel. The information in the current database can be browsed through the web page to understand the engineering construction status; it also includes various applications of rig automation.

The network layer adopts the cellular mobile communication technology that supports high-speed data transmission, that is, the forth-generation mobile communication technology, which can simultaneously transmit voice and data information at a rate of more than a few hundred kbps, while the signal coverage area is large, ensuring large data transmission stability. At the same time, combined with wired Internet and office LAN, the communication between the application layer and the perception layer of the Internet of Things is completed. The perception layer mainly includes the positioning and communication modules of personnel and equipment, and various sensors on the drilling rig that meet the needs of intelligent blasting [3].

4.2. Network topology
The technician transmits the data to the database server through the blasting design terminal, the drilling rig reads the perforation design into the drilling rig industrial control computer through the wireless network, the drilling rig operator automatically or manually locates the hole position according to the navigation interface prompts, and the drilling rig according to the relevant sensor data automatically complete the drilling work of the designed drilling depth. In case of accidental changes on site, holes or additional holes can be quickly drilled according to the authorization of the equipment management terminal. The staff of the blasting team received the charge design of the drilled hole from the network, and according to the GPS positioning module and the automatic equipment of the charge truck, quantitative charge was made from hole to hole. During the detonation, the location information of the demolition warning line and personnel equipment is received through the tablet computer. Relevant information on site, including various sensor data of drilling rigs, usage of explosives, working conditions and records of drilling units and blasting group members, and related materials such as video and audio are transmitted to the database server through the network. The topology of the network is shown in Figure 3.

4.3. Surface terrain model based on 3DMine smart equipment area
The establishment of the surface terrain model of the smart equipment area can not only have a complete understanding of the smart equipment area on the macro level. At the same time, the surface model is also the boundary constraint condition for the next stage optimization. Import the contour lines and marked elevation points on the topographic and geological map into the 3DMine software. Firstly, the
contour lines are cleaned, the duplicate points within the line, the duplicate points between the lines, the duplicate line segments, and the T-angle are cleaned. Then use the automatic connection line tool to connect the contour lines of each elevation on the ground. Then use 3DMine software's equivalent contour line to assign elevation, and assign each elevation point to elevation. The point line file will be assigned with elevation, and the surface DTM file will be generated by 3DMine software. As shown in Figure 4, the generated surface DTM model is displayed in elevation style by 3DMine software [4].

Figure 4. The comparison chart between the three-dimensional ore body model of the ore body and the borehole

4.4. Entity model of ore body
The establishment of the ore body solid model is the most important part in the process of building a three-dimensional model of the mine. It refers to the use of a series of triangles to connect the points contained in the polygon line string to define an entity, thereby simulating the three-dimensional space shape of the ore body. First, import the exploration line profile provided on the mine into the 3DMine software, and then exchange YZ coordinates to stand up the profile; then rotate the profile on the plane according to the azimuth of the exploration line, and finally move it to the marked XY coordinates, so that the profile is placed in the correct position in space. Organize the ore body lines of each section and save them separately as a line file. Then according to the ore body line, connect to form the ore body solid model. Partitioning and extrapolation must also be considered when connecting ore bodies. For ore body lines on a single profile, half of the distance of the exploration line is extrapolated along both sides of the strike direction, and the extrapolated area is half of the original. Finally, the solid model of pyrite is shown in Figure 5.

Figure 5. The three-dimensional map of open-pit development pit line
5. Intelligent smart equipment test

5.1. Parameter selection

The equipment platform can best reflect the advantages of intelligent smart equipment, because the main processes of smart equipment production are rock drilling, charging, blasting, digging, loading, smart equipment, transportation, etc. are inseparable from intelligent equipment. The construction of the intelligent equipment platform is also a process of developing from a single to a whole, followed by stand-alone intelligence, single-link intelligence, and overall intelligence. The stand-alone intelligence mainly refers to the realization of the intelligence of the rock drilling trolley, the charging trolley, the excavator, the lifting transportation equipment and the auxiliary equipment. At present, many domestic mines are undergoing stand-alone intelligent transformation and advancing to single-link intelligent transformation. The process is exactly the difficulty that mines need to break through. The key technology of single-link intelligence is the need to combine equipment and smart equipment processes to realize the intelligence of single production links, so as to take the overall smart equipment process as a starting point, systematically realize intelligent control of process flow, and form an equipment platform on the process flow and operation chain. The final overall intelligence.

In the digital smart equipment intelligent smart equipment technology test, parameter selection is the process of data sorting and analysis after information collection. Mine smart equipment information collection monitoring points are determined through mineral resource assessment. Information collection is also the key to intelligent smart equipment. Mine smart equipment information collection is the only way to obtain accurate information on mine smart equipment. Mine resource assessment is a method of obtaining fuzzy information. It mainly uses artificial field collection information and belongs to a kind of fuzzy information. In the process of data collation and analysis, the two need to be considered together to ensure the accuracy of smart equipment resource data collection and provide a solid data foundation for subsequent visualization. Of course, the smart equipment information includes a lot of content, which needs to be continuously adjusted according to the location of the mine, the type of ore contained and the operational requirements, but the basic information must be selected as a parameter. Table 1 below briefly lists [5].

| smart equipment method | Smart smart equipment | Traditional smart equipment |
|------------------------|-----------------------|-----------------------------|
| smart equipment years  | 5 years               | 5 years                     |
| Annual smart equipment volume | 10 million tons | 10 million tons           |
| Design smart equipment recovery | 89%               | 89%                         |
| Cohesion               | 5                     | 5                           |
| Ore pressure           | 2.4MPa                | 2.4MPa                      |

Through Table 1 we can see the types of digital smart equipment intelligent smart equipment technology test parameters selected, these data into the test model, you can get the intelligent smart equipment technology test results [6].

5.2. Experimental model

In the comparison test between the traditional smart equipment method and the intelligent smart equipment method, the same parameters are selected and brought into different models respectively, so as to draw a comparison between the smart equipment results of the two different methods. In the comparative test of mine smart equipment technology, it is also necessary to analyze the different parameter models of the actual situation of mine resources, so as to select the appropriate test model.

\[ F(S) = a - b \frac{S - 12}{c - d} \]
This formula is an intelligent smart equipment technology test model. The above parameters are brought into this formula to obtain the digital mine intelligent smart equipment technology test results.

\[ F(S) = a - b \frac{s + 12}{c - d} \]  

This formula is a traditional smart equipment technology test model. The above parameters are brought into this formula to obtain the digital mine intelligent smart equipment technology test results. The comparison results of mine smart equipment technology are mainly for the preparation of the smart equipment method selection and are an important step in determining the smart equipment technology method [7].

5.3. Test results

By sorting and analysing the parameters of smart equipment information collection and input into the industrial Internet, the comparison of the two smart equipment methods is achieved through the operation of the test model. The test results are as follows.

| smart equipment method | Intelligent smart equipment technology | Traditional smart equipment technology |
|------------------------|----------------------------------------|---------------------------------------|
| Expected annual smart equipment volume | 12 million tons | 890,0000 tons |
| Expected recovery rate | 91% | 88% |
| Expected cohesion | 8.1 | 4.1 |
| Expected pressure | 1.3MPa | 2.7MPa |

Table 2 is the actual test data results obtained by comparing intelligent smart equipment technology with traditional smart equipment technology. By comparing intelligent smart equipment technology with traditional smart equipment technology, it can be found that the intelligent smart equipment technology of digital mines based on the Industrial Internet can achieve the expected goals and achieve the maximum smart equipment volume, and even exceed the designed smart equipment volume. In the process of digital smart equipment intelligent technology, resource evaluation, information collection and technical smart equipment need to cooperate closely and the actual operation of professionals, so that the smart equipment process is completed with high efficiency and high quality. The intelligent smart equipment technology of digital mines based on industrial Internet can realize the maximum exploitation of mine resources [8].

6. Conclusion

Based on the combination of surface ore body block models in the smart equipment area, selecting reasonable optimization parameters and performing open-air optimization calculations through 3DMINE smart equipment engineering software can provide a variety of price method applications for open-pit smart equipment, which not only improves the performance of mine managers and designers, but also save resources, strengthen the competitiveness of enterprises in the international market, and promote domestic smart equipment companies to better integrate with the international market. However, in the process of optimization, the realm of all module combinations is not considered, and the result obtained is probably not the optimal solution, but it is safe to say that it is very close to the optimal solution.

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References
[1] Huang, C. J. & Jiang, J. C. Research of smartphone industry outsourcing decision model. Journal of information and optimization sciences, 39 (3) (2018) 725-737.
[2] Liu, S. Hu, J., Zhang, R., Dai, Y., & Yang, H. Development of smart equipment technology and equipment for seafloor massive sulfide deposits. Chinese Journal of Mechanical Engineering, 29 (5) (2016) 863-870.
[3] Zhang, J. Yang, M., Xu, B., Ding, R., Cheng, M., & Dong, P. A novel intelligent sliding sleeve for shale oil and gas smart equipment equipment. Journal of Petroleum ence and Engineering, 158 (5) (2017) 1-10.
[4] Silva, F. J. D. S. Viana, H. R. G., & André Nasser Aquino Queiroz. Availability forecast of smart equipment equipment. Journal of Quality in Maintenance Engineering, 22 (4) (2016) 418-432.
[5] Del Castillo, M. F. Godoy, M. C., & Dimitrakopoulos, R. Optimal smart equipment rates revisited: managing smart equipment equipment and geological risk at a given mine setup. Journal of smart equipment Science, 51 (4) (2015) 785-798.
[6] Chupin, S. & Bolobov, V. Influence of thermomechanical treatment modes on wear resistance of smart equipment equipment material. Materials Science Forum, 945 (1) (2019) 695-699.
[7] Chen, S. Yin, D. Liu, X., Wang, H., & Pu, Z. Collaborative smart equipment using different equipment for a coal seam varying in thickness in a long wall working face. International Journal of Oil Gas & Coal Technology, 13 (1) (2016) 73-82.
[8] Trudel, B. Nadeau, S., Zaras, K., & Deschamps, I. Managing equipment innovations in smart equipment: a review. Work, 51 (4) (2015) 731-746.