Design Studies and Intelligence Engineering
L.C. Jain et al. (Eds.)

doi:10.3233/FAIA250261

The Whole Process Operation and Maintenance Management System of Electromechanical Equipment Based on Two-Dimensional Code Mobile Interconnection

Junchao DU[a],Longya LANG[a],Wenting SONG[a],Jiangtao GUO[b,1]
[a]*State Grid Corporation of China,Beijing 100031,China*
[b]*State Grid XinJiang Information & Telecommunication company,Urumqi 830063,China*

Abstract. In order to solve the problem of low efficiency of integrated processing of intelligent operation and maintenance management model of coal mine mechanical and electrical equipment, which leads to long response time of fault identification, the whole process operation and maintenance management system of mechanical and electrical equipment based on two-dimensional code mobile interconnection is proposed. This paper adopts a multi-level approach to improve the efficiency of comprehensive processing, establish a multi-level RFID coal mine electromechanical equipment intelligent operation and maintenance management model, and finally adopt the adaptive auxiliary adjustment to realize the operation and maintenance management. Experimental results show that: compared with the traditional method, the designed RFID technology of coal mine mechanical and electrical equipment intelligent operation and maintenance management method ultimately results in the fault identification response time is better controlled in 0.5s or less, indicating that in the RFID technology with the assistance and support of the designed coal mine mechanical and electrical equipment intelligent operation and maintenance management method is more efficient, and the practical application of the value of the higher significance of innovation. Conclusion: The method of this paper provides a strong guarantee for the high efficiency and safety of coal production.

Keywords. RFID technology, coal mine electromechanical equipment, intelligent operation and maintenance, equipment monitoring, two-dimensional code mobile interconnection

1. Introduction

With the rapid development of China's economy, the demand for energy in all walks of life is increasing. As an important fossil energy source, coal plays a very important

[1] Corresponding Author.Jiangtao GUO,State Grid XinJiang Information & Telecommunication company,E-mail:gjt_1108@163.com.

role in the process of national industrial development [1]. Coal plant is a key link in the production system of coal plant, which is mainly responsible for filtering impurities in raw coal through coal washing and coal selecting process, and sorting different coals, so as to improve the quality of coal [2]. Coal plant has a large number of electromechanical equipment, including belt conveyor, motor, reducer, vibrating screen, etc., once the mechanical equipment failure will directly lead to coal plant shutdown, affecting the output of the coal plant, and may even cause personal accidents [3].

After the coal is mined out, the size is different and contains a lot of residue, not conducive to direct use, so need to use the coal plant electromechanical equipment for separation and selection [4]. Coal plant electromechanical equipment operation directly affects the coal plant enterprise production economic benefits, therefore, the electromechanical equipment supervision and maintenance is very necessary, if you do not pay attention to equipment management and maintenance, then in the use of the process of equipment anomalies, resulting in the coal plant can not be normal operation, coal plant economic benefits can not be effectively safeguarded, and is not conducive to the high-speed development of the coal plant [5]. Therefore, coal plant electromechanical equipment management and maintenance is one of the key concerns of coal plant enterprises, the use of scientific and effective management and maintenance measures, the necessary maintenance of electromechanical equipment, can extend the use of equipment time, so that the equipment is in a smooth and safe operation, which not only ensures the quality of beneficiation, reduce the common failures of the equipment, and reduce the cost of equipment purchases and maintenance [6].

For the coal plant enterprise, coal plant electromechanical equipment management and maintenance is the operation of the basic security, only management and maintenance in time, is beneficial to the coal plant industry's sustainable development concept [7]. Workers to carry out management and maintenance of electromechanical equipment, according to the different types of electromechanical equipment should be done early program, regular inspection of electromechanical equipment and maintenance and repair, and at the same time, record the maintenance and repair information, for the next step in the management and maintenance of a good foundation for the enhancement of the management and maintenance of countermeasures to provide an effective basis. At the same time, do a good job of management and maintenance staff capacity building, through training, evaluation and other measures to improve the overall level of management and maintenance team, to further ensure that the maintenance and management of electromechanical equipment results [8].

2. Literature review

In order to ensure the economic benefits of coal preparation plant and coal quality, it is necessary to ensure the stable operation of field equipment, and strengthen the operation and monitoring of field equipment [9]. Coal beneficiation plant electromechanical equipment is more varied, along the line arrangement is long, the traditional electromechanical equipment operation and maintenance method is carried by the workers with the simplest inspection instrument inspection and check the site equipment, the inspection method exists in low efficiency, inaccurate detection results, and the site of the higher risk factor, these problems seriously constrain the development of coal beneficiation plant [10]. With the advent of the current intelligent era, there is an urgent need to realize unmanned remote monitoring of equipment, improve the

efficiency of operation and maintenance of equipment, and realize the centralization and intelligence of field operations [11]. This paper analyzes the common faults of electromechanical equipment in coal preparation plant, based on the common faults and characteristics of the equipment, researches the remote operation and maintenance technology scheme of electromechanical equipment in coal preparation plant, and designs the software control system, and verifies the advantages and effects of the remote online monitoring system of the equipment after on-site application and debugging [12].

In recent years, the rapid development of the coal industry has made the role of coal plant electromechanical equipment in the production process more and more prominent. However, due to the traditional operation and maintenance management methods, such as Fisher, C et al. proposed a method to set the traditional "1+N" mode coal plant mechanical and electrical equipment intelligent operation and maintenance management method [13]. Yang, C et al. proposed the traditional SpringBoot three-dimensional digitization coal plant mechanical and electrical equipment intelligent operation and maintenance management method, etc., which are mostly set as Although it can fulfill the expected control standard, there are still many uncontrollable limitations, such as: low equipment correlation, uncontrolled management, complicated adjustment and application, etc. [14]. To a certain extent, these problems will form obstacles to the daily application of coal plant mechanical and electrical equipment, affecting the final use of the effect, resulting in poor management efficiency. Coupled with the dramatic increase in the volume of work, the failure rate of the coal plant electromechanical equipment remains high, which seriously affects the efficiency and safety of coal production.

In order to solve this problem, this research is a kind of intelligent operation and maintenance management method of coal plant electromechanical equipment based on RFID technology, and practical verification. The so-called RFID technology (Radio Frequency Identification), in fact, is a radio frequency identification technology, the use of radio frequency signals for communication can be realized non-contact automatic identification processing. The integration of the coal plant with the intelligent operation and maintenance management of electromechanical equipment, can design a more flexible, refined operation and maintenance control mode, the basic principle is to use the spatial coupling and transmission characteristics of radio frequency signals, to achieve the static or moving to be identified items of automatic machine identification.

3. Methodology

3.1 QR code mobile internet technology

QR code is called two-dimensional barcode, is a product of science and technology in the information age, it is not only widely used in life, but also widely used in all kinds of work. The working principle of QR code is to use specific, regular geometric patterns presented in the two-dimensional direction to express information in a graphical way. Through the means of science and technology, various types of data and information can be presented in the two-dimensional code, and the use is very simple and convenient, you can use the image input equipment, or photoelectric scanning equipment to automatically recognize, and then the two-dimensional code in the information presented. In the development of information technology today, the two-dimensional code and our lives are inextricably linked, which not only provides a lot of convenience to our lives, but also helps us to more convenient to understand the cognitively unaware of things. In

the work, the application of two-dimensional code is also very wide, which largely improves the efficiency of the work, and reduces the burden of the work task.

Mobile Internet technology is also an important product of the information age. Mobile Internet technology is also an important product of the information age, mobile Internet technology, that is, mobile terminals and the Internet interconnection, in the traditional management of fixed assets in colleges and universities, the common use of computers to manage fixed assets, compared with paper document management for the efficiency of the work has been greatly improved, but in the rapid development of today's society, and not be able to meet the requirements of the work of the fixed assets management in colleges and universities, because although the computer can be networked, but due to the computer itself is not portable, to a large extent, by the work environment is more restricted, and the mobile Internet technology, can solve this problem, and the mobile Internet technology, can solve this problem. Because although the computer can be networked, but because the computer itself is not portable, to a large extent by the working environment is more restrictive, and mobile Internet technology, you can solve this problem, the mobile terminal, connected to the Internet, not only can real-time view to monitor the management of fixed assets in colleges and universities, but also liberated from the Internet working environment limitations, so that it will not be subjected to the environment and other aspects of the limitations.

3.2 Clarify the operation and maintenance indexes of electromechanical equipment and the placement of sensing points

In the coal plant electromechanical equipment operation and maintenance management, in order to ensure the normal operation of the equipment and safe production, strengthen the daily operation and maintenance control, need to clarify a series of operation and maintenance indicators. First of all, the equipment integrity rate is a key indicator, which can reflect the overall technical status of the equipment to a certain extent, reflecting the comprehensive performance of the equipment. The equipment failure rate is used to measure the status of equipment in unplanned downtime and functional failure, the lower the failure rate, the higher the reliability of the equipment. Next is the operational efficiency of equipment (OEE), from a variety of angles to reflect the availability of equipment, performance and quality. Through OEE monitoring, targeted optimization of operation and maintenance strategies to improve the overall operational efficiency of the equipment. The timely rate of maintenance of equipment maintenance, regular testing implementation rate and other indicators also need to collect specific data and information for subsequent use.

3.3 Establishing a multi-level RFID coal plant electromechanical equipment intelligent operation and maintenance management model

Combined with RFID technology, a multi-level intelligent operation and maintenance management model for mechanical and electrical equipment in coal plants is established. The model will be divided into multiple levels of equipment operation and maintenance management, to further ensure the efficiency and safety of equipment operation and maintenance. At present, we need to design the basic level application structure of the model, the first level is the data acquisition layer, the use of RFID technology on the coal plant electromechanical equipment operating status data collection in real time, set the operating frequency of 165Hz, read-write distance of

20.5~25.5 m. Installation of RFID tags on the equipment, access to the equipment's identity information, location information, operating parameters and other key data . The collected data are uploaded to the data center in real time through wireless transmission, and the data transmission rate is measured, as shown in equation (1).

$$g = \sum_{i=1} \partial i - \kappa^2 \times R \tag{1}$$

Where:g is the data transfer rate;∂ is the number of reads and writes;i is the operation frequency;κ is the repeated transmission of data;R is the number of recognitions.

The data transmission rate will be set as a standard, in the data transmission, the transmission rate control, to avoid the occurrence of data loss, to provide data support for the subsequent level; the second level is the data processing layer, responsible for the coal plant electromechanical equipment operation process collected in the original data cleaning, classification, storage and other processing, to facilitate further analysis and mining. The third level is the data analysis layer, combined with RFID technology, the historical data and real-time data of electromechanical equipment are analyzed in depth, and the operating rules and potential failure modes of the electromechanical equipment in the coal plant are explored. Using the results of data analysis, the performance of the equipment can be evaluated and the possible failures and maintenance needs can be predicted. Based on the above settings, the model expression is constructed as shown in equation (2).

$$D = R^2 - \frac{1}{\mu}(z + s) \tag{2}$$

Where: D for the model output results; R for the RF coverage; μ for the wireless induction area; z and s for the initial operating frequency and the actual operating frequency. Based on the results of the comparative analysis, at the same time, combined with RFID technology, set up fault early warning, intelligent diagnosis and other application modules, in order to help managers find potential problems in a timely manner, formulate the corresponding maintenance plan and maintenance strategy, optimize the configuration and scheduling of equipment, improve the overall operation and maintenance efficiency, and provide strong support for the sustainable development of the coal plant enterprise.

3.4 Adaptive assistance in adjusting to achieve operations and maintenance management

Adaptive auxiliary adjustment through real-time monitoring of equipment operating status, prediction and early warning of potential problems, reduce the failure rate, reduce unplanned downtime, to protect production safety. The current design of adaptive auxiliary adjustment process, as shown in Figure 1.

Combined with Figure 1, the design of adaptive auxiliary adjustment operation and maintenance management process is realized. For the results of the model output, the use of nodes of each coal plant electromechanical equipment for integration and adjustment, through data analysis, to provide maintenance personnel with accurate fault location and maintenance programs. Once the potential safety hazards are found, the warning will be issued immediately, thus greatly reducing the possibility of accidents and stabilizing the operating environment of the equipment.

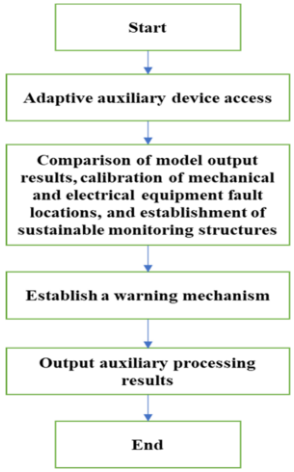

Figure 1. Diagrammatic representation of the adaptive assisted tuning O&M management process

3.5 Common failures and characteristics of electromechanical equipment

Coal plant is a production system used to sort raw coal, through physical and chemical methods of sorting raw coal, in order to get different quality of coal, so as to maximize the utilization rate of raw coal. Common electromechanical equipment in coal plant mainly includes electric motor, belt conveyor, reducer, vibrating screen and slurry dewaterer, etc. Different mechanical equipments are composed of various parts and components, among which, belt conveyor is composed of electric motor, reducer, rollers, conveyor belt, support frame, hydraulic system, etc. Vibrating screen is composed of vibrating motor, screen arm, vibrating screen structure, etc. Due to the relatively harsh environment of the coal plant, electromechanical equipment in the humid, electromagnetic radiation environment for a long time, it is very easy to appear a variety of operational faults, for this reason, the need to monitor and operation and maintenance of electromechanical equipment running status, through the analysis of the coal plant electromechanical equipment common failure can be derived, the most common faults in the coal plant's electromechanical equipment mainly occurs in the motor, reducer, vibrating screen and belt conveyor. Table 1 shows the causes and abnormal characteristics of common failures of electromechanical equipment in coal plants.

Table 1. Analysis and characterization of abnormal causes of electromechanical equipment in coal plants

fault location	unusual causes	parametric characterization
Electric motors	loose stator base, loose core stator coil	Vibration
	gas gap imbalance, gaseous gas gap imbalance	electromagnetic vibration
	Unbalanced rotor operation, large radial amplitude of the rotor	Temperature
Reduction gears	Insufficient oil level	Temperature
	bearing damage	Vibration
	Loose foundation connection of the speed reducer	temperature, vibration
Vibrating Screen	Poor lubrication of the vibration motor, the	Temperature
	Damage to the screen walls of the vibrating screen, the	Vibration
	loose footing connections	Vibration
Belt Conveyor	Cracking of the base of the roller connection	vibration, flow
	Roller	Temperature anomalies
	Roller cracking	vibration, temperature

Table 1 can be seen, coal plant mechanical and electrical equipment in different parts of the failure, will be directly manifested in the corresponding physical parameters of the abnormality, in which the motor failure common failure form for the stator abnormality caused by electromagnetic vibration, vibration caused by the connection between the base and the shell of the looseness of the; reducer of the common failure for the insufficient oil level, bearing damage and the foundation of the connection loosening, etc.; vibrating screen of the common failure for the motor lubrication is poor, screen wall damage and the ground connection loosening and so on. The common failure of vibrating screen is poor motor lubrication, screen wall damage and loose ground connection. Abnormalities in different parts of the equipment are mainly manifested as abnormalities in vibration, temperature, flow and other parameters.

In order to solve the problem that it is difficult to detect the faults of electromechanical equipments in the coal plant in time and operate and maintain them remotely, an online monitoring system for equipment operation and maintenance is proposed to realize remote monitoring and online operation and maintenance of electromechanical equipments in the coal plant. Based on this, the following functional requirements are proposed. (1) Collect the temperature signal, vibration signal, smoke signal and video signal of the electromechanical equipment, and send the collected signals to the upper computer monitoring system to realize the remote monitoring of the equipment. (2) Build a convolutional neural network algorithm to accurately identify and analyze the abnormal features collected at the site, collect gas concentration, temperature information, vibration characteristics and image signals, and iterate the data many times to get the abnormal diagnosis results, so as to realize unmanned intervention and intelligent diagnosis.

3.6 Online monitoring program for remote operation and maintenance of electromechanical equipment in coal plants

Coal plant equipment online intelligent monitoring is mainly composed of three parts: field data acquisition layer, intermediate conversion layer and network communication layer. The data acquisition layer takes sensors as the core, and collects real-time operating parameters from the site by using a variety of sensors, processes and converts the data information by the intermediate converter, and sends the data to the upper computer monitoring system by the network communication layer. Vibration sensors, smoke sensors, explosion-proof cameras, and thermal imaging cameras are installed in the key parts of electromechanical equipments of the coal plant, and the vibration, temperature, and video signals collected on the site can be transformed into electrical signals by the intermediate converter, and the electrical signals are sent to the upper computer monitoring system by the network communication layer. The vibration, temperature and video signals collected on site can be transformed into electric signals through intermediate converters, and the electric signals will be sent to the upper computer monitoring terminal through the network communication layer, and the monitoring system will realize the automatic switching of the screen, which can realize the global view and local zoomed-in view, and collect the video signals in different locations to realize the comprehensive monitoring of the coal plant equipment. When anomalies occur on site, the control system will analyze and judge through the troubleshooting software, so as to get the abnormal information on the site, and by precisely locating the abnormal information to the maintenance point, the organization

personnel can carry out maintenance and processing in time, which greatly improves the monitoring and management efficiency of the site.

3.7 Experimental analysis

The main purpose of this study is to analyze and verify the actual application effect of the intelligent operation and maintenance management method of coal plant electromechanical equipment based on RFID technology, combining with the actual measurement requirements, considering the real and reliable final test results, and using the comparative way to carry out the analysis. References are set to the traditional "1+N" mode coal plant mechanical and electrical equipment intelligent operation and maintenance management test group, the traditional SpringBoot three-dimensional digitization coal plant mechanical and electrical equipment intelligent operation and maintenance management test group, and the designed RFID technology coal plant mechanical and electrical equipment intelligent operation and maintenance management test group. Professional equipment is used to collect information and data, which are summarized and integrated for subsequent use. Next, the basic test environment is built based on RFID technology.

Combined with RFID technology, the test environment of intelligent operation and maintenance management method of coal plant electromechanical equipment is associated and constructed. First of all, five devices in the coal plant project are selected as the auxiliary objects for testing, and then nodes are set in each electromechanical device to facilitate the subsequent operation and maintenance control. After completing the nodes and the test platform, the transmission of real-time data can be completed. Next, combined with the application of RFID technology, the test auxiliary parameters are set, as shown in Table 2.

Table 2. Table of auxiliary parameters for intelligent operation and maintenance management of electromechanical equipment in coal plants

Coal plant motor equipment intelligent operation and maintenance management direct indicator	standardized values of actual parameters	controllable range
Frequency of operation of the equipment/Hz	205	185~265
static control ratio	3.55	2.16~3.68
operations and maintenance management phase	Integration phase + control adjustment phase	integration phase + control adjustment phase + targeted analysis phase

Combined with Table 2, it realizes the setting of auxiliary parameters for intelligent operation and maintenance management of electromechanical equipment in coal plant, based on which, the construction of test environment is completed.

4. Results and discussion

In the test environment constructed above, the intelligent operation and maintenance management method of coal plant electromechanical equipment is measured and verified by RFID technology. First, data collection is summarized using nodes, and next, RFID is used to set tags for the coal plant equipment, and the tags are imported into the management program. Subsequently, through the set monitoring device to identify the operation of the equipment, the development of auxiliary fault test

instructions, start instructions, the current program combined with RFID technology to calibrate the location of the fault, calculated at this time the scope of the fault, as shown in Equation (3).

$$M = (\pi - \chi^2) \times \frac{S}{\gamma} \tag{3}$$

Where: M for the operation and maintenance management fault range; π for the basic operating efficiency; χ for the operating efficiency after the failure; γ for the identification of the region; S for the repeated identification of the location. Combined with the current measurement, in the identification of the sensing of the O&M fault range, the use of RFID radio frequency technology to accurately locate the virtual fault location, and ultimately measured the fault identification response time, which is shown in Equation (4).

$$K = v - \sqrt{(1 + \kappa^2) \times o} \tag{4}$$

Where: K is the fault recognition response time; υ is the preset failure rate; κ is the recognition speed; o is the operation and maintenance control RFID operating frequency. Combined with the above measurements, the realization of the test results of the comparative analysis, as shown in Table 3.

Table 3. Comparative analysis of test results

Equipment	"1+N" model/s	Traditional SpringBoot /s	The method of this paper/s
Equipment 1	1.13	1.26	0.42
Equipment 2	1.02	1.52	0.13
Equipment 3	1.06	1.03	0.19
Equipment 4	1.13	1.18	0.28
Equipment 5	1.08	1.19	0.29

Combined with Table 3, the following conclusions are drawn: compared with the traditional "1+N" mode coal mine mechanical and electrical equipment intelligent operation and maintenance management test group, the traditional SpringBoot three-dimensional digital coal mine mechanical and electrical equipment intelligent operation and maintenance management test group, the designed RFID technology coal mine mechanical and electrical equipment intelligent operation and maintenance management test group ultimately The response time of fault identification is well controlled below 0.5s, which indicates that with the assistance and support of RFID technology, the designed intelligent operation and maintenance management method of coal mine mechanical and electrical equipment is more efficient, and the practical application value and innovation significance are higher.

5. Conclusion

This paper proposes the whole process operation and maintenance management system of electromechanical equipment based on two-dimensional code mobile interconnection, RFID technology assistance and fusion support, can establish a set of real-time monitoring, early warning and intelligent diagnosis of the complete operation and maintenance management structure, and effectively improve the reliability and stability of the operation of the equipment through the experiments can be seen, after the

application of the proposed method, the fault identification response time is better controlled at 0.5s, the application of the effect of better, can provide efficient and safe security for coal production, and can be used to protect the coal production and safety. The proposed method can provide a strong guarantee for the high efficiency and safety of coal production.

References

[1] Zhang, T. , Wu, H. , & Chen, X. . (2024). Research on construction technology of communication mechanical and electrical engineering. Voice of the Publisher, 10(1), 7.

[2] Dong, L. , Chen, N. , Liang, J. , Li, T. , Yan, Z. , & Zhang, B. . (2023). A review of indoor-orbital electrical inspection robots in substations. Industrial Robot: the international journal of robotics research and application, 50(2), 337-352.

[3] Slavutskii, A. L. , Andreev, O. N. , Russova, N. V. , & Galanina, N. A. . (2024). Transient at finite switching time: monitoring by neural net. Russian Electrical Engineering, 95(8), 651-655.

[4] Maphosa, P. , Nziu, P. , & Masu, L. . (2024). Criticality analysis of electromechanical equipment maintenance. a case study in sasol synfuels catalyst preparation unit. International Journal of Engineering Trends and Technology, 72(1), 93-100.

[5] Zhigang, J. , Qing, Z. , & Wei, H. Y. . (2023). A task-driven remaining useful life predicting method for key parts of electromechanical equipment under dynamic service environment. The International Journal of Advanced Manufacturing Technology, 125(9/10), 4149-4162.

[6]CHEN Jian. (2022). Study on evaluation scale of equipment and facilities of tunnel electromechanical subdivisional project based on k-means algorithm. Journal of Highway and Transportation, Research and Development, 39(11), 143-150.

[7] Chi, H. . (2024). Construction safety management of mechanical and electrical installation projects. Journal of Architectural Research and Development, 8(2), 50-54.

[8] Liu, Y. , & Zhao, Y. . (2022). Electrical automation control technology of electromechanical equipment based on artificial intelligence technology. Journal of Physics: Conference Series, 2181(1), 12045.

[9] Fisher, C. . (2024). The newest and best in tools and equipment for hvacr and automation. Electrical apparatus: the magazine of electromechanical & electronic application & maintenance, 77(3), 42-43.

[10] Yang, B. , Zhang, J. , & Yuan, C. . (2023). A load control strategy for stable operation of free-piston electromechanical hybrid power system. Journal of Dynamic Systems, Measurement, and Control, 145(11), 1-7.

[11] Brzozowski, C. . (2023). Electrified construction equipment. Electrical apparatus: the magazine of electromechanical & electronic application & maintenance, 76(4), 19-21.

[12] Hucko, S. , Matthiesen, G. , & Schmitz, R. K. . (2023). Investigation of magnetic force hysteresis in electromechanical actuators. Chemical Engineering & Technology: Industrial Chemistry -Plant Equipment -Process Engineering -Biotechnology, 46(1), 158-166.

[13] Fisher, C. . (2024). The newest and best in tools and equipment for plant and shop. Electrical apparatus: the magazine of electromechanical & electronic application & maintenance, 77(2), 40-41.

[14] Yang, C. , & Zhang, X. . (2024). Multi-domain mapping design method of automatic disassembly equipment for small electromechanical products. Proceedings of the Institution of Mechanical Engineers, Part C. Journal of mechanical engineering science, 238(5), 1182-1202.