ANALYSIS OF CONDITIONS MONITOR AND FAULT SYNTHETICAL DIAGNOSIS OF MECHANICAL AND ELECTRICAL EQUIPMENT IN MINE

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Abstract

For the special working condition of equipment under coal mine, taken common fault appeared in major mechanical and electrical equipment of Datong Coal Mine Group as example, effective methods of conditions monitoring, fault diagnosis and examining and repairing are summarized. It achieved the goal of predicting fault in advance, maintaining conditions and improving the efficiency of equipment. The actual application result shows that the technology can achieve reliable and efficient working of equipment; it also provides protection for high-yielding and efficient produce.

Key words: mechanical and electrical equipment of coal mine, fault diagnoses; condition monitoring, equipment maintenance.

1 Introduction

For the modern coal mine，the fully mechanized coal mining equipments are the basic machine for production. A high degree of mechanization is the biggest advantage of mining. At present, fully mechanized coal mining equipments of high production and high efficiency are quickly developing, and in the great majority of coal mines fully mechanized coal mining equipments have being used, and semi-automatic mining has be realized basically and fully automated mining is being achieved the step by step.

Fully mechanized coal mining equipments includes shearer, three machines (face conveyor, beam stage loader, crusher), hydraulic support, pumping station (emulsion pump and spray pumps) and 3.3KV power substations and control equipment. Double-ended ranging drum electrical haulage shearer is composed of five parts; they are left and right ranging drum cutting devices, left and right haulage devices and center controller. The left and right ranging drum and haulage device are separately composed by electromotor, gearboxes and bearings. The armoured flexible conveyor can be divided into five parts: the head, the tail of the drive (motor, limiting-moment couplings, gearboxes, and sprocket components), the pans, the flight bars, chain and the body frame. The beam stage loader is a special flight bars conveyor, it is short than face conveyor. The driving device of beam stage loader is similar to face conveyor; it can move following the working face. The crusher is linked with the beam stage loader. High-pressure liquid (emulsification liquid) is the power of the electro-hydraulic control hydraulic support. It is supporting equipment composed by several hydraulic parts (cylinder, valve) and metal structures (top beam, cover beam, base, four-link staff, etc.) to support and manage the roof. Emulsion pump is the important equipment of pumping system. The crank and connecting pole mechanism linked with motor and the gearboxes realizes reciprocating movement of the piston.

The gate belt conveyor and the main shaft belt conveyor are composed by drive device (electrical motor, controlled start transmission CST, drum), belt, idler,

body frame etc. The gate belt conveyor contains belt-storage devices.

2. Fault analysis on fully mechanized coal mining equipments

This paper gives a detailed discussion on the condition monitoring, the fault diagnosis and the management of fully mechanized coal mining equipment.

According to the statistics for mining equipments usage in Datong Coal Mining Group Company in the past three years, in all of the fully mechanized coal mining accidents, equipment accidents accounted about more than 60 percent, and roof and end accident, the coal bunker full accident accounted about 20 percent apiece. In fully mechanized mining working face, electromechanical accidents occupied 38.8% to 41.8% (shearer accidents occupied 51.5% and conveyor accident occupied for 31.6% and electrical accidents occupied 16.9% among them).The shearer incident ranks first in equipment accidents, followed by working face conveyor accidents, level road transports equipment accidents and electrical accidents. At present, the main factors affecting the operating rate are the electromechanical accidents of the fully mechanized coal mining equipments, the coal bunker full, the short supply of train wagon, the support and end failed to keep pace, the abnormal of working procedure**,** etc. Incident will greatly affect the operating rate of the fully mechanized coal mining equipments, so the reduction of the incidents is one of the most important for improving the operating rate. Therefore, the downtime caused by the electrical and mechanical failure reflects the reliability and the reasonable selecting of the equipment as well as the level of the equipment operation and maintenance. In order to realize high efficiency of the fully-mechanized face we must do everything possible to improve the operating rate of the equipments.

Which positions was the fault incident in fully mechanized coal mining equipments on earth?

The electrical and mechanical failures of fully mechanized coal mining equipments occurred 223 times during 2007 in Datong Coal Mining Group Company. The failures occurred 175 times on parts of equipments and cost 1461.4 hours, which occupied 78.2% of the total failure time. Divided by the position of faults, the statistical results shows below:

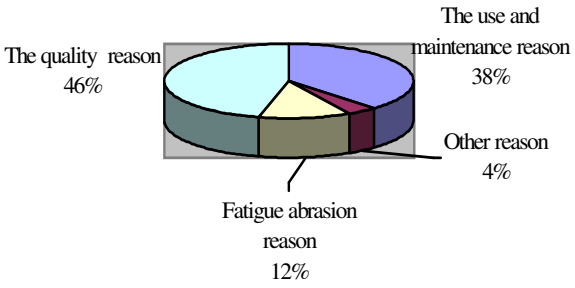
Tabel1 Statistics of position of equipments failures in 2007

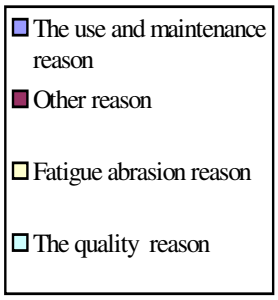
No.	Failure site	Times	Downtime（h）	Fault downtime per10,000 tons coal（h/10000 tons）	Percentage（%）
1	belt conveyor (tired belt, belt broken)	21	368.4	0.05	19.7
2	the flight bars conveyor (chain broken, broken flight bar)	36	228	0.03	12.2
3	shearer haulage device	31	235.2	0.03	12.6
4	shearer ranging drum	22	180	0.02	9.6
5	gearboxes	26	167	0.03	8.9
6	motor	30	206	0.03	11.02
7	converter	5	57	0.02	3.05
8	CST, transformer	4	20	0.03	1.07
9	other failures	48	407.2	0.08	21.8

The equipments and parts where were prone to fault that affected production are showed in table1. They are various motors, coupler connected with motor, reducer and its main parts (such as bearings, gears), roller, belt, transformer, cable, etc.

The electromechanical equipment failures occurred 23 times in Aug 2007 in Datong Coal Mining Group Company. The failures affected production about 201.4 hours, and fault downtime per10000 tons was about 0.35 hours. The failures distribution divided by the fault reason is showed in figure1.

Figure1. All kinds of reasons depicted in this figure





The fault reason in figure1 corresponded to the source of the failures roughly, such as design and manufacture of equipment, installation and maintenance, operation and equipment deterioration and so on.

Through the careful analysis on failures of fully mechanized mining equipments, the main reason leading to failure or destruction of equipments was often the additional load caused by the load dramatic change and improper dynamic parameters of the system during the working process of shearer, boring machine, hydraulic support, face conveyor, etc.

From the macroscopic viewpoint, the follows are the reason of the equipment failure:

(1) Error in design: stress concentration, too much stress, unsuitable materials or coordination, inappropriate lubrication method, ill-considered about the affection of using condition and environment condition and so on.

(2) Raw material defect: material can't meet the technical requirement, castings and forgings flaw, and so on.

(3) Manufacture flaw: machining, pressure processing, assembly defect, welding flaw, heat treatment deformation, and so on.

(4) Question during operation: the affection of unpredictable conditions, change of application conditions, such as overload, overheating, corrosion, poor lubrication, operation errors, improper maintenance and repair, etc.

From the microcosmic viewpoint, the reason about mechanical failure is that the strength and stress factors of parts are incompatible with the environmental factors in the equipment. The fault types of mechanical and electrical equipments include mainly deformation, abrasion, fracture and corrosion. Among them abrasion is the most common, and the consequence of fracture is very serious, and deformation of basic pieces is often not seriously noted, and corrosion is always related closely with the peripheral environment of equipment.

The state of equipment will have directly to do with production quality, production efficiency and production safety. Therefore, firstly, it is necessary to monitor continuously for the health state of the mining equipment using advanced equipment maintenance and management methods; secondly, according to the characteristics of mining equipments, monitoring technology should be applied pertinently; thirdly, a new management system for repairing and maintenance of equipments should be established. The system should include condition monitoring, spot inspection maintenance, fault diagnosis, prediction maintenance and so on in order to solve fundamentally the problems appeared on equipment management and realize equipments service life extension and scientific management and rational use, predictive maintenance and safety running.

3 Analysis methods of the synthetically diagnosis for fully mechanized mining equipments' fault

In recent years, with the improvement of technicality in mining equipments the technique of equipments' fault diagnose is working up from the simple monitoring to exact diagnosing, and from simplification instrument to synthetically diagnosing system, and from out of line to online monitoring, and from qualitative to quantitative analysis, and from monitoring to diagnose unto the maintenance management.

By statistic analysis on the accident places, failure of electrical and mechanical equipments such as shearer, face conveyor, beam stage loader, belt conveyor were always on shafts clouding gears, bearings, seal and imbalance etc. In addition, other some faults also take often place such as the electrical motor and electrical fault, hydraulic system failure, structural part deformation, chain broken and the belt torn overload and so on

We should use different diagnosis method for different fault. If we can realize monitoring the electrical equipment, electronic control systems, bears, hydraulic system, oil and emulsion, working condition, sensors and temperature, pressure, flow, voltage, vibration, acceleration, speed, displacement, force, torque and other physical parameters, the condition monitoring will be played an important role for safety production and avoiding direct or indirect economic losses. It is an introduction for methods of the common fault diagnosis in Datong Coal Group Company as follows.

3.1 Ferrography analysis method in oil analysis

Wear of parts is one of the main faults on the equipment and 80 percent of the equipments' failure is wear failure. The wear happened between the relative moving parts in mechanical system. The lubrication of equipments reflects and determines the status of the operation. Only well lubrication, the equipments can be well operation, so it is necessary inspecting the situation of equipments' lubrication regular. In practice we analyze the oil of the equipments to detect and to prevent equipments' failure.

Ferrography analysis is a good way to monitor equipments' lubricant in common use. It can monitor efficaciously ingredient of particles and their change in oil, and detect the degree of oil pollution and deterioration by rule and line. Basic principle of iron spectral analysis is that the iron grains are first separated in the lubricants by means of magnetic method (using ferrography instrument) ,and they deposit no superposition on a transparent-on-chip by the size of it in turn (that is making ferrogram), and then we can detect and analyze the surface shape characteristics and composition of the wear particle by the microscope or directly observed in the naked eye, and then we can estimate the place of wear, the extent of wear, the development trends of the fault and the causes of the fault and so on.

The coal mining machineries in fully mechanized coal mining face are in bad working environment such as humidity, heavy dust etc. They are mostly moving equipments of low-speed and heavy load and accompanying with the strong impact and vibration in the working process. Ferrography analysis method is a better way for monitor the failure of the equipments. It is to get oil from equipments to analyze the mechanical drive system and to monitor the status of the operation.

Examples:

The more than 1000 oil samples was gotten from the MG-300/700-WD shearer in Meiyukou coal mine from February to June in 2007. Analyzed for the oil samples of the left ranging drum of the shearers by the ferrography analysis technology the wear particle intensity was 966. But when we observed by the microscope the quantity of wear debris had not increase and pollutants had become greater. According to the phenomena we considered the pollution had been very serious, so we replaced the oil in time and avoided a serious accident. In accordance with the situation of a cutting motor damaged frequently in a period of time, After analyzing for the ferrography in the oil samples we found that there were part of the normal wear particle (<15um) and a small quantity of cutting debris, a small quantity of fatigue type stripping pieces (16~30um), part of layered wear particles (<46um), a small quantity of fuscous metal-oxide and friction polymer, a small quantity of spherical particles and coal debris and so on less than 3 u m in diameter on the ferrogram, and in the light of these condition we thought that the electrical motor bearings had occurred fatigue failure because of the bearings lubricated badly. After we improved the structure of lubrication system on time, the electrical motor bearings had been operating well.

The oil sample was once gotten from the No.1 gearbox of the SSJ-1000/200 belt conveyor in fully mechanized coal mining team of Dadougou coal mine in August 2007. A rolling bearing was estimated in abnormality because the large quantity of spherical particles was found in the sample. After checking we found that a rolling bearing frame of the second axis had worn. Due to finding and disposing on time, a shutdown fault was avoided.

Practices show that the ferrography analysis technology is an important and effective method for condition monitoring and predicting, maintenance.

3.2 Diagnosis equipment using vibration analysis

The deterioration of the condition would cause equipments the abnormal vibration in running because of many reasons such as operation, surroundings and so on, at the some time, the vibration were main cause of the equipment destruction. When fault will occur on the equipment, vibration frequency of the equipment is often

changed. Through detecting the vibration's frequencies, speed, acceleration, displacement, phase and other parameters and using vibration frequency analyses method we often analyze some faults such as rotor imbalance, un-alignment of the shafts, structural resonance, the bearings and gears meshing for the rotating machinery for example the motor, the gearbox and other types rotating machinery. From analyzing results we could find the reasons of the vibration change and take action to avoid malfunctions.

3.3 Ultrasonic diagnosis

The reflecting ultrasonic will become unconventionality when ultrasonic gets across a crack, so we could determine the status of cracks by means of ultrasonic technology. Ultrasonic monitoring technology is to detect the size, the form and the distribution of the outside and the inside defects using materials' disfigurement influence on the spread of ultrasound. It is widely used in detecting the internal defects of the machine component.

3.4 Acoustic emission (AE) diagnosis

AE diagnosis method is a dynamic and nondestructive detection. Based on characteristic and intensity of acoustic emission that is produced when the micro-cracks and cracks of the material come into being and expand, the state (presence, location and the extent) of sound fountain could be deduced, so we could know the historical states of the cracks and forecast their development trend.

AE method can always monitor the internal structure continuously and predict the life of structure, so it has been widely used. By means of AE approach we usually analyze plastic deformation of the metal, monitor the wire rope core of powerful belt conveyor and the wire rope of hoist, detect fatigue crack growth, monitor the operating status of machinery, assess the structure disfigurement of pressure vessels such as boiler, and detect the crack of the welding process and so on. Getting information by AE it is easy to find the damage of equipment and the development of the damage, and make sure the damage extend. It is worth mentioning that it has better applied to forecast underground rock burst and other geological disasters, and improve mine safety. A SOS slight shock monitor system was introduced into Xinzhouyao coal mine from Poland in 2007. The system is making use of acoustic emission technology. It can use to take place directional crack of rock body, and analyze the impact pressure, and improve the mine maintenance conditions.

3.5 Infrared diagnosis

Temperature is an important parameter token operation condition of the equipment. An evidence characteristic is the increase of temperature when electrical failure or mechanical failure takes place in equipment, at the same time the increase of temperature may cause the failure of equipment. So temperature is consanguineous related to operation condition of equipment and inspection for temperature play an important role in fault diagnosis of equipment. There are a lot of methods of temperature measurement, but the infrared technology is in the most common use. It gets the temperature distribution by means of measuring the infrared radiating from equipment (such as the temperature distribution of heating pipe) and determines whether the equipment is in natural.

As the infrared temperature measurement has many advantages such as contactless, portable, fast, intuitive and recordable and so on, so now the technology has wildly used in the condition monitoring and fault diagnosis of equipment. We have been using portable infrared measure equipment to determine the failure several years.

3.6 The computer monitoring and diagnosis

When a large number of equipments are needed monitoring and diagnosis or when the key equipments are needed continuous monitoring, collection frequently and analysis and comparison for the data is very heavy work. Then automatic monitoring and diagnosis by computer can save a lot of manpower and ensure objective results. For example the large-scale mining equipments on-line monitoring system with computer monitoring and diagnosis technology has been successfully applied in Sitai coal mine. Some parameters were taken out from the equipments such as the signal RMS or peak coefficient and compared with the reference value of the standard state. According to the result whether the fault would take place is judged. It diagnose for the abnormal condition further to determine the type and location of the failure and predict development of the failure.

Condition monitoring and fault diagnosis online has be very effective in improving the reliability and

validity of mining whole set equipment, especially equipment of some only artificial measures in the past have changed to automatic monitoring and when failure may occur voice alarm provided. At the same time we can improve the monitoring quality and enlarge the monitoring content combining the computer monitoring and diagnosis with the expert analysis system.

4. Conclusion

According to statistics by the relevant authoritative departments of Europe, American, Japan and other industrial developed countries, due to the implementation of condition monitoring and fault diagnosis technology, major safety accidents are reduced by 50 percent in enterprises, the machine-stopped time is reduced by 40-60%, equipment maintenance costs are reduced by 10-25 percent, and the overall rate of return on investments reaches 1:17. According to prediction by Chinese relevant departments, these indicators should be higher than that of industrial developed countries for some internal enterprises of extensive management.

It should be said that condition monitoring and fault diagnosis technology has been greatly expanding and improving regardless of its technical itself or its application scope and application effect. To achieve a planned and targeted maintenance according to condition may reduce maintenance time and storage of spare parts，improve the quality of maintenance and equipment maintenance management level. Therefore the use of advanced diagnostic equipment for monitoring and forecasting of fault hidden is an urgent problem. In order to develop and extend the new technologies such as condition-based maintenance, life management, risk management and so on condition monitoring and fault diagnosis technology should be combined with advanced equipment management idea. This is a main development direction of mine electrical and mechanical equipment condition monitoring and fault diagnosis technology. This point has been proved in practice.

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