Discussion on Realization of Unmanned Fully Mechanized Mining Technology

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Abstract. This paper pointed out the key technology and existing problems of intelligent and unmanned fully-mechanized mining face. The solution to the key technical problems was given. The study proved that intelligent production model was an effective means of the unmanned mining in fully mechanized coal mining face, and had the application value of promotion in thin and relatively thin seam where the geological condition was good.

Introduction

Intelligent unmanned mining refers to a variety of key technologies can break through the harsh environment of fully-mechanized mining face, including of transmission of information security, coal and rock identification, straightness control of mining face, posture positioning of mining equipment, safety awareness, video monitoring, remote control, etc. It forms a set of detection, control, video, audio, communications, which integrates intelligent control system of fully-mechanized working face, to ensure continuous, coordinated, efficient and safe operation of the fully-mechanized equipment, to realize intelligent, management information, and unmanned operation of the working face production process.

Realize less humanization and unmanned mining in the coalmine fully-mechanized working face is a hot spot of research on the current mining industry. The United States, Germany and Australia's unmanned mining technology of fully-mechanized working face are relatively advanced. In Australia, the use of LASC long wall automation system of fully-mechanized coal face has exceeded 60%; a set of thin coal seam long wall equipment has been developed in US recently, and has been planned to be used in Norway to realize unmanned mining.

Safe and efficient coal mining is an important industrial policy and goal, automation and control technology of mine unmanned mechanized mining face and its application as an important measure to achieve safe and efficient mining of coal, are the important manifestations of the coal industry advanced productivity. Thin seam coal mining industry has been plagued technical problems; especially thin seam mining is particularly difficult.

At present, a lot of domestic units have carried out the unmanned and less humanized (automated mechanized mining face) study in China. In May 2005, Datong Coal Mine Group has realized the first domestic thin seam coal cutter fully-mechanized working face. In 2008, Yujialiang Mine 44305 Face of Shenhua Shendong Coal Group Co., Ltd. has became the first domestic fully-mechanized working face automation of shearer. In 2012, Xue Cun Coal Mine 94702 Face of Jizhong Energy Fengfeng Group has realized remote automated mining. They laid a foundation for the domestic exploration of fully-mechanized working face especially unmanned mining of thin coal seam working face.

The special research test target of intelligent unmanned mechanized mining technology is to study the mining thick coal seam in domestic equipment fully-mechanized unmanned technology, including shearer control and remote manual intervention techniques, hydraulic support with machine automation and remote manual intervention technology, fully-mechanized mining equipment order to run concurrently, ground remote control technology.

The main experimental contents of intelligent unmanned mechanized mining technology are:
(1) The unmanned mining technology in thin seam mining conditions.
(2) Form a complete set of domestic equipment type selection of the unmanned mining of thin seams.
(3) The technology solutions for the unmanned mining of thin seams.
(4) The production application for the unmanned mining of thin seams.

The Key Technologies of Intelligent Unmanned Mechanized Mining

Unmanned as the basic goal of intelligent comprehensive mechanized coal mining, the main technical difficulty is the need to use remote control the production process, which is a set of automation, detection, video, communications, control, computer integrated application of multiple technologies. The main key technologies need to be solved as follows:

1. Hydraulic support full face with machine automation and remote manual intervention
   On the basis of hydraulic supports electro-hydraulic control system to achieve full automation of the working surface with the machine, according to combine with the data of the electro-hydraulic control systems and hydraulic support video, manual intervention hydraulic support through remote monitoring center console, In order to meet the automatic control of hydraulic support under complicated environment.

2. Full working memory of shearer cutting with remote manual intervention
   On the basis of Shearer to achieve full cutting on Face Memory, according to combine with the Shearer real-time data and the video, manual intervention shearer through remote monitoring center console, In order to meet the automatic control of shearer under complicated environment.

3. Face video monitoring technology
   According to the actual circumstance of working face, to design and install the appropriate video monitoring system, to implement the fully-mechanized working face video monitoring in the underground monitoring center and the ground dispatching command center.

4. Fully-mechanized equipment centralized control technology
   Working face automation important mining equipment, including shearer, hydraulic support, transportation systems, power supply systems, liquid supply systems are connected by a communication control technology, to realize centralized control in the underground control center and centralized dispatch control ground command center, and "one button" start and stop.

5. Hydraulic control system for intelligent integration
   Through PLC control technology, remote dosing, emulsion pump, spray pump station, high pressure filter, frequency conversion control system in series, to form intelligent integration for fluid control system, to improve the level of automation systems for liquid and operational efficiency, reduce the system loss and energy consumption.

Main Technical Problems

The main technical problems encountered during the test are:

1. Coal winning machine's own original 14 quadrant mining technique can't meet the mine actual production process, resulting in both ends of the head back knife swept coal process is not complete, the miter difficult and triangle coal feed cannot be normal cutting, etc.

2. Coal cable during exhumation often stack that falling from the cable channel, not only requires manual in time, it will also affect the realization of coal mining face automation.

3. Originally designed camera for every six stents provided with a set of coal wall camera and a set of brackets camera, but in the remote mining process, because the coal wall video (main display drum and support beam situation) in with machine process setting a larger pitch and a brief video blind, affect remote operation safety.

4. Water treatment systems for liquid remote station at design time only set up two-stage filtration system, wherein the first stage filtering accuracy 60μm, secondary filtering accuracy 5μm, such a large filtering accuracy, can easily result in secondary filtration filter blockage, and ultimately affect the normal operation of the water treatment system.

5. Due to the remote station at the liquid supply system is mainly composed of water treatment and automatic dosing system components, and the two systems of design and control is not the same
company, resulting in the actual operation of water treatment systems cannot achieve automatic water supply, the class also need someone to set up the operation monitoring.

(6) In actual production process of the working face, moving frame caused the problem of hydraulic support tilt after pushing slip due to conveyor decline, causing frame shift difficulties and equipment damage, affecting the normal production.

(7) Since the use of coal in the way combined with internal rotation on the drum to increase and other reasons, resulting in poor inner coal spraying, fogging effect influenced, eventually lead to coal dust is bigger in the process of working face coal cutting.

(8) Due to the use of small tube, and the fuselage water supply shortage, Lead to coal spray secondary spray no pressure, don't spray, influence effect of dust prevention in working face.

(9) Machine installed on the fuselage airborne infrared transmitters, to show the location of the plow, but the transmitter used on the 12V power supply is taken from the coal-powered panel, and because the coal around the start in the process of cutting drum of starting current is big, power supply voltage fluctuations is heavy, often leading to emitter instantaneous power outages, eventually leading to the automatic control system cannot read the stoker position in a timely manner, the impact of hydraulic Support automatic with the machine.

(10) Loader tail and tip brackets cannot automatically lapse action, each operating they both use the original control way forward to complete the loader forward movement.

(11) When the establishment of the ground control center, since the large amount of data transferred ground from underground to ground, ground video and data transmission delay serious.

(12) When a remote mining operation happens on the ground, because the connection is only by telephone, the workers on the ground cannot understand the situation of equipments and operators in down-hole, and ultimately affect the safety of the ground remote mining operations.

The Solution of Main Technical Problems

(1) For the underground coal mining technology, reworked coal mining technology of twenty-two quadrant according with the actual mining process, effectively solved the sweep back knife coal incomplete and difficult triangle coal cutting knife sweep, also achieve the purpose of the tip holder with automatic machine. At present, the innovation has been successfully applied for a patent.

(2) Through the study of the heightening of cable trough block coal plate 200mm to effectively solve the cable bracket exhumation process problems. At present, the innovation has also been successfully applied for a patent.

(3) For the video dead affect remote operation security problem, by way of increasing the coal wall surveillance camera in the working face, install one coal wall video camera every three bracket, install one video camera every six bracket, install PTZ camera in head, in order to achieve all-round monitoring. Obtain the shearer position by the infrared sensor, by software processing to achieve seamless cutover of Camera Follow Shearer. Achieve all-round monitoring coal conveyor rollers and the support beam in the remote monitoring process.

(4) Two-stage filtration system of water treatment systems by poor accuracy greater and affect the secondary filter clogging frequently, for this question, first replace the water supply pipe from roadway to face into the spray pipe (formerly pipe, prone to rust), to ensure clean water supply system; secondly make full use of original useless horizontal hydraulic filter station of fully-mechanized working face, by removing one of the filter vat, in which increase a set of filter filtration precision 25µm,to form a new filter, installed between the existing primary and secondary filtration device, effectively solves the filtration accuracy is poor due to paralysis treatment system failure, greatly improving production efficiency.

(5) Water treatment control system is integrated, and the remote station control fluid for application has been updated, in the production process, realized the purpose of automatic adding water, for liquid based on emulsion concentration, water level, etc.

(6) Use the bracket side guards cylinder to adjust bracket angle, reverse the top beam cylinder lines, so that one side of the guard plate bracket formed around a shrink stretched, stretched it out a reduction of the state, and then complete the bracket adjustment ramp work. By this kind of
adjustment method, moving face not only can adjust more quickly, while also improving the quality of regulation of the stent. The innovation has now also successfully applied for a patent.

(7) In the drum spray set up a dedicated line (factory within the spray cooling water supply and arm the same waterway, and the cooling water for the open-loop control), and within the existing waterway will be closed spray treatment, greatly improving the internal flow and spray atomization.

(8) A set of L type external type spray device is designed to install, effectively control the dust when cutting coal situation, and has taken the 100 mm thick cable clamp replacement for 145 mm thick cable clamp, to achieve the purpose of increasing the main water supply line, effectively solve the problem of fuselage water shortage, no pressure, etc..

(9) Using the original coal winning machine near idle start the knob on the control panel to control the output of 12V power transformer alone lead to the near-idle knob on the control panel, using the button to manually control the airborne emitter start-stop of the 12V power supply, at the same time within the infrared transmitters installed a "watchdog", effectively solve the infrared transmitter power unstable power supply, and restart the problem.

(10) Through repeated analysis the working time of face loader self-moving and end frame action, and ultimately added loader self-moving system to the automation of electro-hydraulic control system, to achieve self-moving of reproduced machine and end bracket in the process of working face with machine, reduce labor intensity of workers, but also further over Face automation control level, and laid the foundation for unmanned mining.

(11) In the original transmission cable, select two cores as a dedicated transmission line, and the video data transmission to the ground control center separately, to effectively solve the terrestrial video and data transmission delay problem.

(12) Set up voice communication platform on the ground, installed network video and audio decoder and a signal processor and other facilities in the underground, the use of the shaft transmission cable up and down, implemented well voice dispatching communication up and down, video calls and voice warning function device is turned on.

Various Benefit Analysis

From the point of safety benefits, Intelligent unmanned mining moving workers from the mining face of high risk to security environment better gateway monitoring center even to the ground control center, to improve job safety factor fundamentally. In order to promote high-risk industry to the intrinsically safe, intelligent unmanned mining provides a reliable technical support.

From the point of economic benefits, intelligent face are all made of domestic equipment and technology, a preliminary estimate of the price of domestic coal mechanized mining outfit intelligent system is about two-thirds of foreign products. A face outfit smart system is expected to save users around 30 million equipment purchase costs. Compared with conventional mechanized coal mining, the work area during the production of the original nine joint operations (coal drivers 3, 5 bracket workers, transport drivers 1) reduced to one person patrol, alone annual savings of 500 million, artificial efficiency reached 133 tons/ worker. Two trough ahead single support mode to automatically advance support bracket mode, class 8 operation by the remote operation is reduced to four (two each return air inlet, one person operation, one person monitoring), Cost Efficiency, labor cost savings per year more than 8 million Yuan. The number of single-class production jobs from the previous 19 people (including the driver and electrician belt 1 each) to seven people.

From the point of social benefits, application of intelligent unmanned mining technology, dramatically reducing the labor intensity, coal miners working environment from the past "dirty, bitter, dangerous and tired" to now sitting on the floor wearing a suit and tie mining, realized workers happy work, happy life, improve the social status of coal mine workers, set up the coal enterprise good social image. Intelligent production is the direction of technological development of the coal industry. The successful application of this project has an important and far-reaching significance to improve the level of technological equipment of the coal industry, coal equipment to create a national brand, promote the transformation and upgrading of the coal industry.
The Main Innovation Points to the Research on Intelligent and Unmanned Fully-Mechanized Technology

The main goal of this project is in the further study based on unmanned fully-mechanized centralized control technology and equipment, use domestic equipment, through continuous field application research to ensure that all equipment can work coordinately, continuously, efficiently and safely try to liberate workers from working face, to centralized automatically control fully-mechanized equipment in the gateway monitoring center or ground scheduling command center, so as to realize normalization of unmanned mining of the fully-mechanized coal face.

The innovation points to the project are as follows.

(1) Put forward control system of the automatic control mode, the extension automatic control mode, the extension centralized control mode, which are the independent and compatible of each other. Put forward the control mode of mainly equipment automation, complementally remote intervention control. built up system frame of mainly complete sets of equipment total control network information comprehensive decision, complementally single equipment to perform.

(2) For the first time, realize "one key" start-stop in scheduling command center ground, and to comprehensively control underground fully-mechanized equipment through the ground work station.

(3) Combined with triangle coal cutting technology, truly realize the triangle coal cutting automatically.

(4) Through electro-hydraulic control system to realize the transport machine tail move since the linkage and the starting equipment’s automatically.

(5) Automatic operation is stable, high production and efficient.

Unmanned mining technology liberate workers from dangerous mining face to the transportation tunnel control center which are relative safe, to control of equipment remotely, and even the ground monitor room. It improves the safety factor of the front-line workers. It can completely replace the technology and products of abroad. It has important practical significance on fully-mechanized working face in China, especially the thin coal seam. It changes workers from operators into inspectors, greatly reduces the labor intensity of workers, improves the operation conditions; improves the yield of coal and coal resource recovery, effectively reduces the waste of resources. The realization of normalization of unmanned mining in coal face is a milestone to promote the development of unmanned fully-mechanized coal winning technology, regardless of China and the world.

References


