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Development of Position System of a Roadheader on a Base of Active IR-Sensor

Markvardt Roman^{a*}, Breido Josif^a, Drijd Nikolay^b

^aBulvar Mira 56, main bld. 140, 100027 Karaganda, Kazakhstan

^bBulvar Mira 56, 2nd bld. 302, 100027 Karaganda, Kazakhstan

Abstract

The article is dedicated to development of remote control system of a roadheader. The main purpose of this system is to decrease a number of emergency situation with fatal outcome related to sudden outbursts of coal during the tunneling work. In the system infrared sensor with active illumination is applied to improve the reliability of positioning of the roadheader in the absence of visual control of the operator.

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1. Introduction

Roadheader is a mining machine designed to destroy the rock mass, rock mass loading on vehicles (trucks, conveyor, reloader, etc.). It applies when driving mountain horizontal and inclined workings, shafts, construction of tunnels. Distinguish tunneling machines with selective and continuous destruction.

Selective destruction roadheaders - the machine swept the executive organ with milling crown, equipped with, as a rule, cutting tool, ensuring the development of the face of any cross-sectional shape.

The machines can be divided into three categories:

- light - of weight up to 35 ton
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* Corresponding author. Tel.: +7-701-557-6450.

E-mail address: markvardt@yandex.ru

- medium - of weight up to 55 ton
- heavy - of weight up to 55 ton.

The roadheader realizes three main operations: cutting, loading and transportation of run-of-mine to other means of transportation. [1]

The main components of roadheader are (Fig. 1): mining system – cutter jib with cutter heads (1), turning base (2), loader (3), stage loader (4), caterpillar chassis (5), hydraulic pack (6), electric equipment box (7).

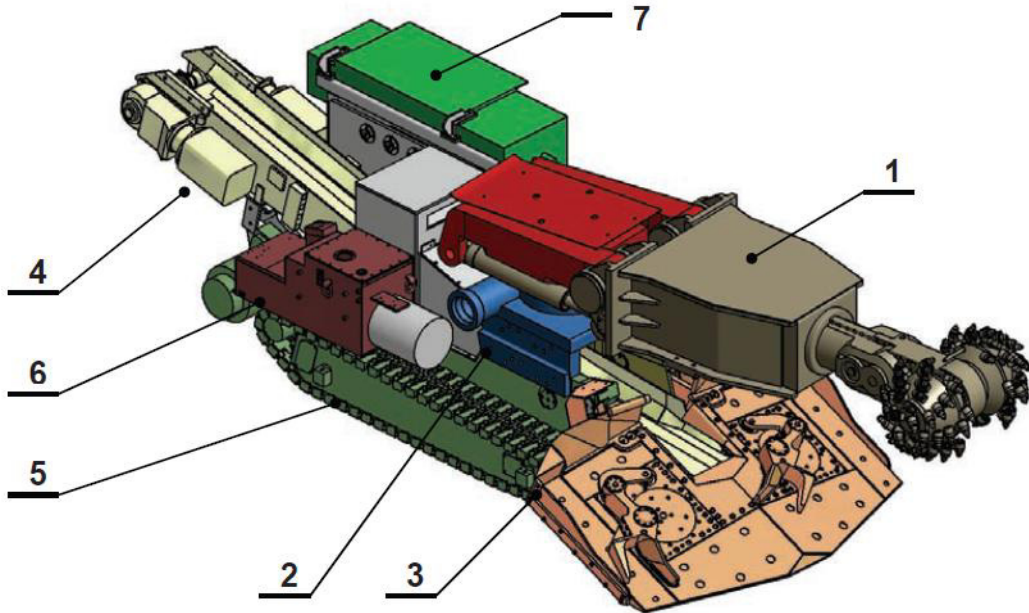


Fig. 1. Design of R-130 roadheader[2].

Roadheader in coal mines is an especially dangerous object, as when it works the destruction of rocks under pressure take place. When sudden outbursts of coal and rock, also emits a large quantity of gas (mostly methane). The concentration of methane in air mixture after the ejection can reach 100%. This leads to a significant loss of human life.

2. System development

The remote control is one of the most important aspects when working with roadheaders, because its presence significantly reduces the risk of accidents during the tunnel works.

Manufacturers from other countries equip their tunneling machines with the most modern control systems. For example, the roadheader R75 German manufacturer dh Mining systems equipped with a remote control system for all functions performed by the roadheader. Weight of the roadheader with all optional devices is 75 tons. In addition to the destruction of rock cutting harvester is capable of sinking of the drilling and blasting method. Remote control of all these functions can be accessed using a wearable remote control at a distance of 35 meters.

In addition to roadheaders already equipped with remote monitoring and control systems, there are manufacturers of optional equipment for retrofitting existing roadheaders with radio remote control systems. An example of such equipment can serve CATTRON control complex produced by the American company CATTRON. This complex consists of two separate modules, one of which collect and process information about the state of the technological equipment installed on the roadheader, and the second module is an operator panel, which displays

relevant information about the state of the equipment. In addition, the remote controls all functions of the roadheader. The disadvantages of this system include the limited range of its application, as connecting the main control unit to a roadheader made by CAN-bus. This means that such a system can only be used on roadheaders already equipped with this bus, or to equip existing roadheader CAN bus. It should be noted that the equipment of the roadheader with bus will almost complete replacement of all sensors, control valves, as well as, in some cases, replacement of the electrical power supply system. Such a deep modernization will cost of comparable value to the cost of modern roadheader.

In the CIS, one of the most modern tunneling machines are harvesters manufactured by JSC "Kopeysk Machine-Building Plant" series KP21.

Combine KP-21 is an upgrade of road headers 1GPKS, which is one of the most common roadheader in the Karaganda coal basin.

First roadheaders KP-21 with remote control was released in 2006. In order to ensure safety at work roadheaders in mines prone to sudden outbursts of coal and gas developed a project and the mass production of roadheaders modifications KP21-02 and KP21-03 with remote control. Such an embodiment allows of the roadheader to work at a relatively safe distance from the working face with wearable cable or radio remote control. In order to increase the drifting rate and reduce non-productive manual labor in the construction of anchoring prepared a draft of the roadheader KP21 with mounted drilling equipment. This system provides wearable remote connected to the control station with a cable length of 15 m, and the local control panel mounted on the driver's workplace and equipped with a display for displaying information on the operation and system failures

One of the most innovative system of the remote control for roadheaders is SKD-2M [3]. It based on a level sensors and laser combine position sensors CPK-2.

In Polish institute KOMAG developed multi-layer artificial neural network for control system of a roadheader.[4]

Remote control system design is roadheader real-time state monitoring strategies which make drivers acquire the current roadheader body posture position posture and the cutting head position in the remote operating room. Thus system was developed by China researchers[5]

All of these systems have a range of remote control about 30-35 meters. However, according to statistics sudden outbursts of a coal, rock and gas can take place over longer distances. So, according to the Department for Emergency Situations of the Karaganda region for the period 2008-2013 yy in the mines of the Karaganda coal basin occurred 5 emergencies with fatal outcome related to sudden outbursts of coal during the tunneling work. As a result of these tragedies died 43 people. When sudden outbursts of coal happened fall of ground length from the working face for four accidents ranged from 18 to 40 meters. In one case, the total length of the fall of ground was more than 700 meters. From these statistics, it follows that the range of the remote control for safe tunnel works is 1 km away or more. This distance for remote control is practically non-achievable in the mine, as at a given distance from the tunnel face are plenty of other manufacturing operations require direct human intervention. To significantly reduce the number of fatal accidents is sufficient to increase the range of control, at least up to 100 meters away from the working face. However, this raises a number of technological problems, mainly which is the inability of the operator to control visually conducting tunnel works.

To solve the problem of remote control the roadheader without visual control of the operator is necessary to solve a number of problems.

First of all, it is necessary to develop a system for low-level data acquisition and control all the actuators combine. For this it is necessary to analyze the concepts of the power section of the most common in the Karaganda coal basin of tunneling machines. So the roadheader harvester series is 1GPKS. The main elements of the system of collecting information will be sensors that determine the position of the working body of the roadheader, as well as tilt sensors of the roadheader housing. Besides it is necessary to provide replacement of manually operated hydraulic control valves to control valves with the electronically controlled. For the considered roadheader these valves are made now. In addition to better control the state of the power equipment by operator in the hydraulic and electrical circuits of the roadheader will be introduced sensors to collect information about the load on the roadheader. Under abnormal loads on the roadheader it will be stopped and the operator will receive an error message.

The next step in the development of remote control system roadheader is the creation of an information exchange system between the operator's wearable remote control and the roadheader, which can provide a continuous wireless connection under strong electromagnetic interference, as well as a rate to set the criteria for the static and dynamic characteristics of the combine. To create this system it is necessary to conduct a series of simulation and practical experiments to determine the allowable delay in the processing and transmission of the signal. The most important parameter is the verification of authenticity and integrity of transmitted data packets. Since the distortion of the

transmitted information can occur emergencies. [6]

System that provides linear motion of the roadheader with various obstacles that arise when moving the of the roadheader is the most difficult from a technical point of view. This system should continuously monitor the position of the body of the roadheader in three planes. This is to ensure the accurate performance of tunnel works. On the basis of this system will be calculated position of the working organ and transmitted to the operator to ensure the visualization process. Currently, such systems exist for continuous tunneling machines, but has a low reliability. Most of these systems are based on the laser sensors with reflector system (Fig. 2). So the system shown in Figure 1 consists of a laser pointer 1, 2 and three reflector sensors 3. This system was developed at the Institute of Innovative Technologies EMAG in Poland. [3]

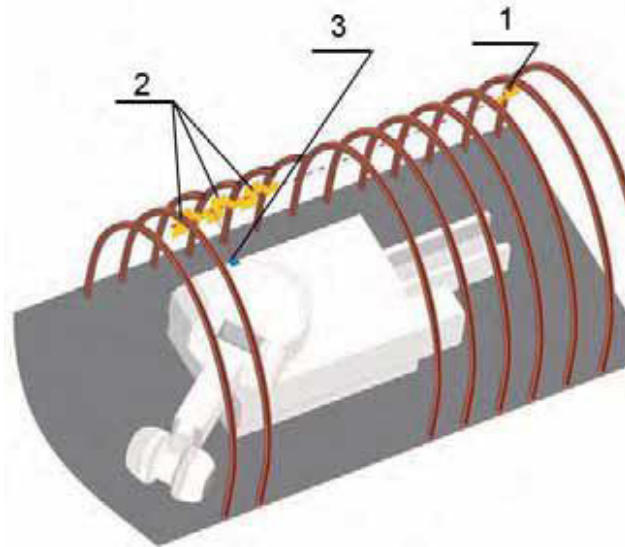


Fig. 2. Method of assembly of reflectors on ribs of the tunnel housing.

In the developed system is planned to implement the infrared distance sensors with active lighting system. The receivers will be located along the axis of movement of the roadheader at random. Transmitter signal is located on the roadheader's body. When the roadheader will be turn on system initialize its position in space. Thus on the basis of sensor readings will be calculated the position of the of the roadheader, and the working body. If the any of roadheader's elements will be heated to a temperature equal to the temperature of the infrared radiator, the radiator change its operating temperature. Such a system should ensure maximum reliability and accuracy.

After determining the position of the roadheader's body operator must specify the cross section generation with a wearable remote control. In this case, the remote control system calculates the position of the working organ and necessary movement for the treatment of the face. When the contour is processing should be automatically selected the rate of processing based on the strength characteristics of broken rocks. Operator will be permanently displayed position of the working organ and the load on it.

Also as a part of the remote control system of roadheader will be emergency condition monitoring system of gas environment and operability of the electromechanical roadheader system to increase the safety of tunnel works.

The study also evaluated the effect of bandwidth management for precise control actuator. To do this, used a mobile robot Robotino with connected to the wireless network software Matlab [7,8]. Research on the real object are difficult because of works in an explosive atmosphere, and because of problems with the financing of research of Ex-type elements of control system was not possible.

Conclusion

As a result of the introduction of remote control tunnel boring machine will increase the level of mine safety, reduce the likelihood of death due to sudden outbursts of coal and gas, will increase the rate of tunnel works.

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