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Analysis of machines work time during machinery and equipment supply for longwalls

Machinery and equipment supply to longwalls is related to the launch of a mining excavation and is one of the key elements of hard coal beds exploitation. The process is based on supplying all indispensable machines and devices to the longwall so that the exploitation could proceed efficiently. In order to ensure better efficiency, it is necessary to find the causes of breakdowns within the process and to counteract them successfully. The objective of these operations will be to raise the production preparedness of machines and devices involved in the process. The increase of this preparedness depends largely on the technical condition of employed machines and devices and their proper selection. This will ensure failure-free and downtime-free progress of the operations.

Key words: *machinery and equipment supply to longwalls, failures, machines*

1. INTRODUCTION

Each organization should create such rules and regulations that would enable to achieve a specific order. These rules and regulations should have realistic features as far as their degree of specification and flexibility are concerned, as each organization should catch up with the changing operating conditions.

Machinery and equipment supply to the longwall is related to the launch of an excavation. The process is based on placing a chain conveyor and powered support in the roadway, installing winning machines, making suitable hydraulic and electric connections, and providing proper communication means.

Machinery and equipment supply is one of the key elements of hard coal exploitation. In order to ensure better efficiency of this process, it is necessary to find the causes of breakdowns and to counteract them successfully. This is done to increase the production preparedness of the machines. Based on thorough reports and analyses of failures it is possible to find weak points of the process as well as facilitate and optimize the work of people and machines. Thanks to the obtained information we know where to invest and where to make changes. The discussion undertaken in the article is related to the process of machinery and equipment supply to the longwall with due regard given to the important roles of machines and devices used in the process.

2. MACHINE SYSTEMS IN MINING

A machine is a device for performing useful work based on the supplied energy or processing one type of energy into another. According to the EU regulations (directive 89/392/EU) a machine is composed of connected elements out of which at least one is movable. A machine is also a set of single machines which are connected in such a way that it works as a whole. The usability of machines is demonstrated, most frequently, as the processing of matter carried out in the working system of the machine [4].

The operating principle of the machine and its control systems should be dedicated to the user's needs. The way the machine is operated by the user, positions of its particular assemblies, parts, lighting, and the user's body posture have significant impact on the accuracy of performed work. The following domains of knowledge describe dependencies between machines and humans [6]:

– Bionics – a domain situated on the border between technology and biology; a new scientific branch which originated from the efforts of biol-

ogists and electronic engineers. Bionics – a science dealing with the study of living organisms and biological processes in order to use them as patterns for technological structures – etymology: **bio**(logy) + (electro)**nics.**

- Ergonomics – a domain of science dealing with rules and methods to adapt devices to human physical and mental features. Ergonomics – a science studying relations between the working environment and psychological and physical capabilities of a human being – etymology: from the Greek **érgon** – work and **nómos** – natural law.
- Anthropometry – a branch of anthropology dealing with human body measurements and proportions – etymology: from the Greek **ánthrōpos** – human; **metréō** – measure.

Underground coal mining makes use of a wide variety of machines in order to increase the output and work efficiency and to improve working conditions.

The following groups of machine systems are used in hard coal mines:

- Machines working in faces, such as: shearers/ploughs, loaders, conveyors, and supports. As the faces move due to advancing exploitation, these machines are movable or walking. This group also comprises machines and devices for stowing exploited excavations.
- Machines for preparing development workings – usually self-propelled or sliding.
- Machines and devices for underground (horizontal) transport – conveyors or underground railway systems.
- Machines for vertical transport – winders. These are stationary machines which transport mined rock, materials and people along shafts with the use of ropes.
- Machines for sorting, enrichment and transport of mine rock to the surface – stationary devices.
- Pumps for dewatering underground excavations.
- Stationary fans placed on the surface, near ventilation shafts. There are also movable fans which work in underground excavations in places where circular ventilation is not available.
- Machines and devices for power supply, indispensable for proper operations of the mine (electric energy, compressed air, water).

The increasing exploitation efficiency results in longer operating ability of machines and devices, fewer breakdowns and downtimes, proper organization and maintenance. This way it is possible to maintain production continuity, increase efficiency, improve the quality of products, and reduce exploitation costs of machines and devices, i.e. reduce the costs of production and the final product [8].

3. MACHINES AND DEVICES WORK TIME DURING SUPPLY OF MACHINERY AND EQUIPMENT TO THE LONGWALL

Machinery and equipment supply to longwalls is, in the most general sense, the preparation of excavations for mining in the shortest possible time. The excavations are prepared with respect to mechanical, electrical, mining, and hydraulic aspects.

In addition, the process includes the preparation of mined rock transport by means of belt conveyors in bottom roads. The following underground machines and devices are employed in the process:

- suspended and floor-mounted railways,
- locomotives,
- winches,
- power supply generators,
- self-propelled chain hoists,
- impact wrenches.

Figure 1 features a sample diagram of the support of a longwall at the crossroads with a face.

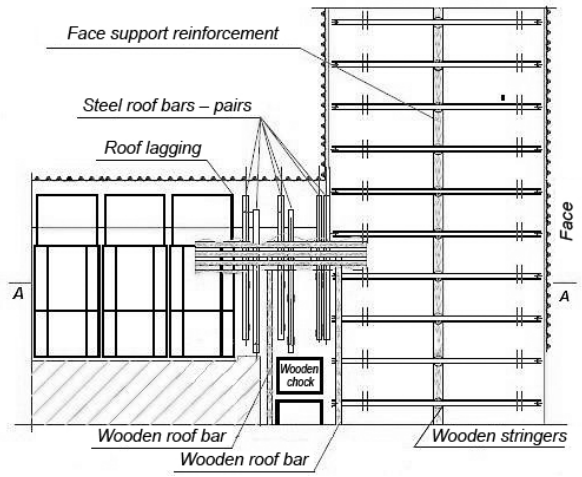

Fig. 1 Longwall support at the crossroads with a face

The technical condition of employed machines and devices, as well as their proper selection, ensure failure-free and downtime-free progress of the machinery and equipment supply. Therefore the supplied equipment should comply with strict technical and security requirements.

Here the key issue are failures which make the equipment unable to perform its useful work. Failure frequency is closely related to reliability and is impacted by working conditions, age of the machine and the personnel's abilities.

As far as new machines are concerned, failures result from constructional, technological and material errors, as well as too short testing time of the proto-

type. In the case of old machines, in turn, failure causes lie in the wear of elements and subassemblies.

According to Polish regulations, a failure is a violent and unexpected breakdown or damage of a building, mechanism or device, which results in breaking its working continuity or deprives it of its properties. More frequently, however, a failure is understood as a technical breakdown happening due to mechanical, electrical or hydraulic reasons and making it impossible to continue one's work safely and in compliance with valid regulations.

As it was mentioned earlier, the machinery and equipment supply process is an important element of the mining process. Failure-free and properly performed machinery supply results in suitable start-up and exploitation of the longwall which, in turn, brings certain financial effects to the mine.

Figure 2 features a sample longwall after a completed machinery and equipment supply process, ready for exploitation.

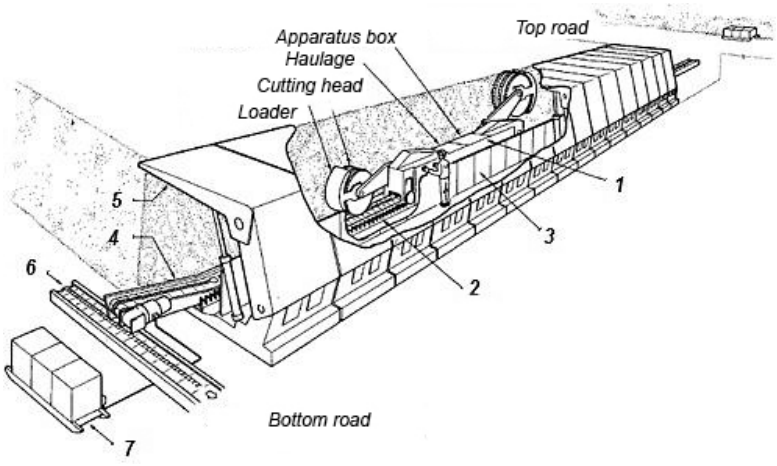

Fig. 2 Shearer longwall face ready for exploitation:
1 – shearer, 2 – ladder, 3 – gate,4 – chain conveyor, 5 – support, 6 – (chain) beam stage loader, 7 – apparatus box

The block diagram in Figure 3 presents the factors which determine the use of nominal work time:

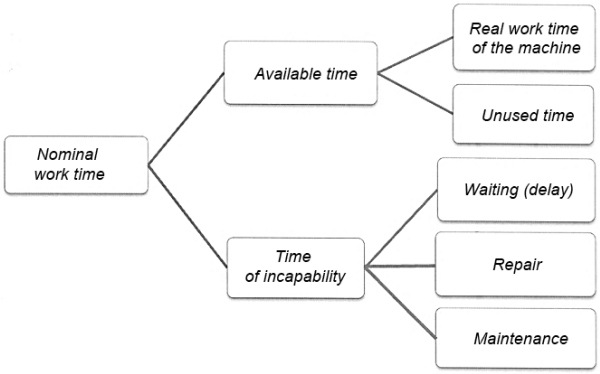

Fig. 3 Use of nominal work time of a machine

The following factors significantly influence the nominal work time of the machine (Fig. 3) [1, 7]:

- the exploitation of machines and equipment while they are usable (in full working order),
- failure frequency related to reliability,
- time of repairs and maintenance (prevention),
- delays in repairs which prolong the period of the machine disability.

Planned shutdowns during the machines operation result from the characteristics of their exploitation processes. Each machine or device has certain checkups scheduled by the manufacturer: periodical, detailed or shift-related checkups. The objective is to test the current technical state of the device and prevent any possible breakdowns that might happen during its operation. These works include, for example, checking oil, cleaning fuel filters, checking the coolant level, etc.

4. DOWNTIMES IN THE PROCESS OF MACHINERY AND EQUIPMENT SUPPLY TO THE LONGWALL

The machinery and equipment supply process, the succession of performed tasks and related downtimes (both planned shutdowns and failures) are presented in Table 1 [5]. The analysis was made for a longwall in a coal mine belonging to the JSW S.A. coal mining company.

Table 1

Machinery and equipment supply process and downtimes

Stages	8 days	7 days	9 days	10 days	18 days	5 days
Installation of suspended railway	18 pcs	90 pcs	125 pcs	60 pcs		
Wrenching of pipes ϕ 180		200 m	240 m	260 m		
Wrenching of pipes ϕ 120		210 m	230 m			
Setting of support unit			31 pcs	50 pcs	35 pcs	
Installation of cable protectors			25 pcs	5 pcs		
Floor underworking		15 m	16 m	12 m	16 m	
Installation of top sections		56 pcs	56 pcs			
Installation of a shearer				Installation of a double-ended ranging drum shearer		
Installation of the first route			Route layout, structure assembly, belt installation			
Installation of the second route			Route layout, structure assembly, belt installation			
Installation of pans of the beam stage loader				Installation of pans and gates	Installation of pans, chain, scrapers	
Installation of pans of the belt conveyor				Installation of scrapes		
DOWNTIMES due to failures	–	–	–	×	×	–
DOWNTIMES due to other reasons	×	×	×	×	×	×

To better illustrate the issue, the process in the longwall was divided into four stages (Table 1). To show the exploitation time of the machines supplied to the longwall, some machines for transporting indispensable materials were used, i.e. suspended railways.

In the course of the machinery and equipment supply process, which according to Table 1 lasted 57 days, there were 8 downtimes out of which 6 were due to exceeding values of the machine parameter while 2 were caused by breakdowns.

In general, the total number of downtimes (8) can (and should be) treated as the time of disability – unplanned breaks in operational continuity. The main reason for 6 downtimes of the suspended railway were exceeding temperature values of water used for cooling the exhaust fumes of the railway. Therefore the downtime needed to be long enough for the temperature to reach the desired level – each time over one hour. In one case there was an exceeded temperature value of oil in the suspended railway, caused by the oil decrease. Due to this event it was necessary to supply oil which caused a downtime of almost one hour.

The remaining two failures were caused by breakdowns of the hose which supplies oil necessary for setting winches.

Due to the occurred events, the planned tasks were not completed during the scheduled shift.

The total work time with downtimes that caused disturbances in the process was presented in a diagram in Fig. 4.

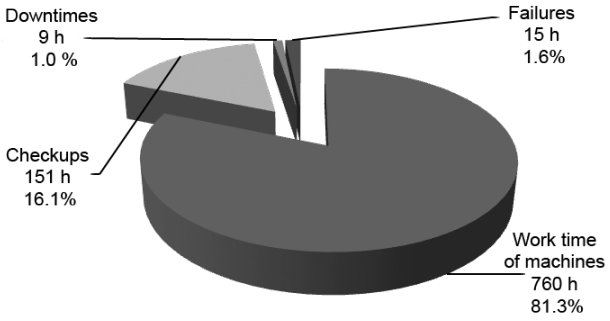

Fig. 4. Efficient work time and downtimes of machines and devices during their supply to the longwall

5. CONCLUSIONS

The issue of maximal possible use of machines work time is present in practically all industrial sectors. Hard coal mining is not an exception here, as each time a downtime happens it is necessary to analyze the causes of failures of those machines and devices whose downtimes impact the operational continuity the most.

The analysis should show whether the failure was caused by one of the following:

- human factor (improper exploitation, maintenance and service),
- the machines as such (errors in construction and manufacturing),
- other causes, for example difficult working conditions.

After completing the analysis it is necessary to identify actions to be undertaken by the relevant personnel in order to reduce the number of downtimes and to improve financial results of the mine.

The following conclusions can be drawn from the analysis of the machinery and equipment supply process described in the article:

- downtimes and failures which occur during the process are related mainly to machines which transport heavy elements to the areas where the process takes place,
- the main reason of failures proved to be very difficult climatic conditions in the mine, i.e. high humidity and air temperature.

A properly performed machinery supply process accompanied by adequate selection of machines and devices to the existing geological and mining conditions [2, 3] have a significant effect on future production efficiency and financial results of the mine.

Failures of particular machines and devices result in major losses for the mine. Therefore it seems justifiable to launch such actions [8] that would help reduce the number of potential failures.

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