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Optimalization of the transport of excavated material in hard coal mines based on improvements in the automatic control mode

Hard coal mines are increasingly struggling with the widespread phenomenon of the decarbonization of the economies of European countries. As a result, they are forced to constantly look for opportunities to reduce unit mining costs. This is extremely difficult because producers of mining machinery and equipment are unwilling to incur high costs for the research and development of new products, as this industry is burdened with a high risk of unprofitability. This article describes one of the examples in which an attempt was made to reduce the costs of hard coal mining by modifying the method of controlling underground haulages consisting of belt conveyors in the Polish LW "Bogdanka" mine.

Key words: *conveyor belt, control mode, automatic*

1. INTRODUCTION

The mining haulage of excavated material, made by belt conveyors in underground mining plants, is a key element of the coal mining process [1]. It is therefore extremely important to ensure its smooth operation and to limit the number of stops of individual conveyors forming the haulage of excavated material from the longwalls and tunnel digging areas. The efficiency of such haulage has a direct impact on the production results of the entire company. Therefore, the search for improvements in this area is absolutely justified.

2. THE SEARCH FOR COST REDUCTION SOLUTIONS

In the LW "Bogdanka" mine, the most effective hard coal mining plant in Poland and characterized by innovative technical solutions, it was decided to try to increase the efficiency of the mine haulage of excavated material operations based on the existing equipment – belt conveyors with control systems already installed and operating in underground workings. It should also be noted that key hauling made of belt conveyors in the LW "Bogdanka" mine operate remotely, from positions located outside the haulage route, including from the surface.

3. NEW CONCEPTION OF CONVEYOR CONTROL

A group of engineers employed at LW "Bogdanka" during their postgraduate studies at the AGH University of Science and Technology in Krakow created a diploma thesis entitled *Optymalizacja transportu urobku przenośnikami taśmowymi* under the supervision of prof. Arkadiusz Kustra [2], where an in-depth analysis of factors disturbing the operation of underground mine haulage, such as the start-up times of

belt conveyors and the cumulative transport times of mined material from the wall to the retention points, during which the stopping of any element of the haulage chain means a break in the entire mining process. The discussed study also included a technical proposal to improve the process of transporting excavated material, which was later implemented for general use in the coal mining process at the LW "Bogdanka" mine. The analysis of factors affecting the continuity of the work of the haulage of excavated material consisted of writing down all the processes which occurred during the operation of individual belt conveyors during their normal operation and interpreting these processes as a function of time.

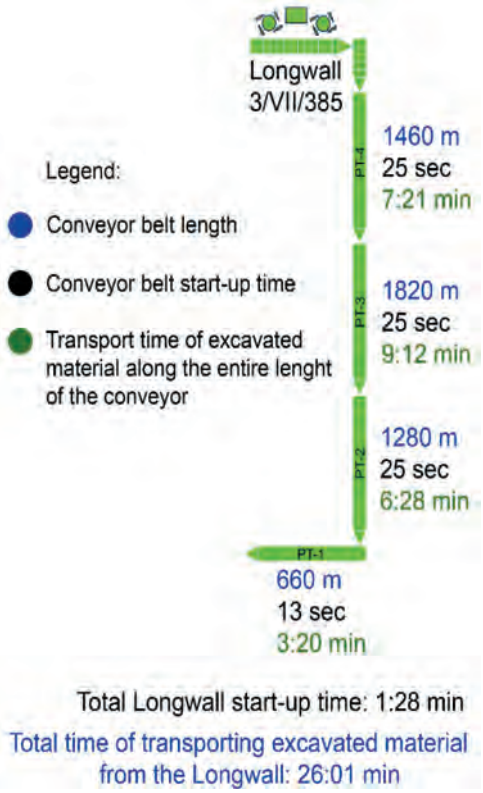

Fig. 1. Analysis of key times in the excavated material haulage system

The following conclusions were drawn from the observations made:

- undesirable start-up times of each conveyor are unavoidable using the currently available technical means, and no possibility of eliminating them or significantly shortening them has been found;
- the transport time of excavated material on long conveyors is so significant that it is in these spaces that efficiency improvements should be sought.

Therefore, it was decided to remodel the automatic operation mode of excavated material haulage by changing its algorithm, taking into account additional data provided to the system.

In the previous automatic haulage operation mode, the entire conveyor chain was stopped from the point of failure to its end, which in such cases led to the stopping of mining machines [3].

The new concept assumes the introduction of the "mining material presence" parameter to the local conveyor controllers algorithm, so that if this information is not confirmed, conveyors that are not at risk of covered by mined material will not be stopped despite the preceding conveyor being stopped. As a result, not every stop of the conveyor during hauling results in stopping the operation of the longwalls and tunnel driving areas, because the new control system can use the empty spaces of the conveyor belts as a time buffer, which is used to remove the ongoing fault.

Elektrometal SA, a company providing control systems for mining, has modified its Elsap-05 system by changing the algorithm of the automatic operating mode according to the instructions of engineers from LW "Bogdanka" mine. Additionally, this manufacturer designed and manufactured a new element of the control system called the COU-22 "mined material presence" [4] sensor for the needs of this project.

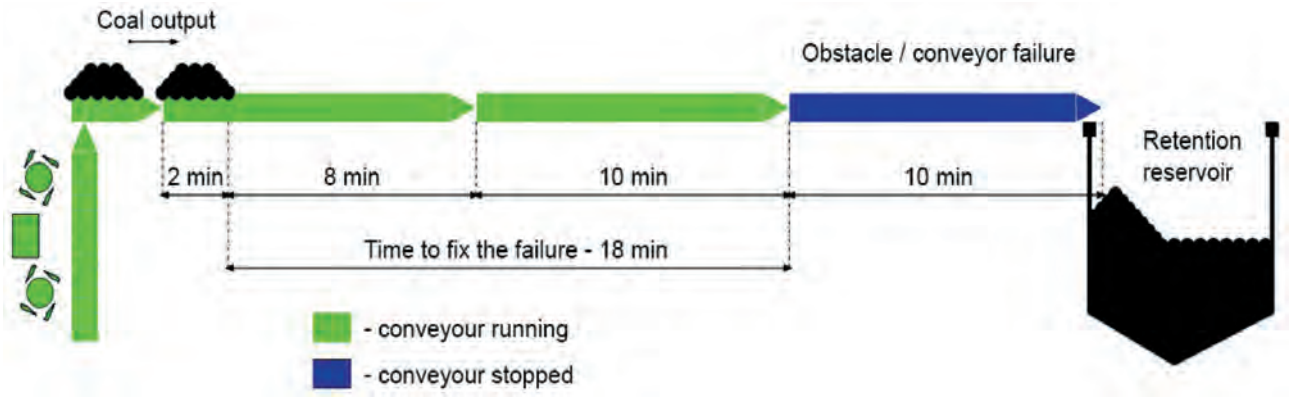

Fig. 2. The idea of controlling the haulage of excavated material in intelligent control mode

This sensor allows you to mechanically determine the presence or absence of mined material in key places along the haulage route and transmit this information to the local controller. Additionally, in local controllers, in order to distinguish the innovative operating mode from the others, it was called the "intelligent" mode.

Fig. 3. Excavated material presence sensor

Thanks to the use of this innovation, the conveyor control system can provide increased time for active haulage of mined material for mining machines and at the same time shorten the time of emergency stops in the mining process.

LW "Bogdanka" mine has already had several months of experience with this solution, and the results demonstrate the effectiveness of this idea in use conveyor strings both at longwalls and tunnel driving areas.

Examples of results obtained on the haulage of excavated material from the tunnel driving area with the implemented "intelligent" mode system on only one conveyor are presented in Table 1 (daily observations) and Table 2 (weekly observations).

As can be seen in the tunnel driving area, the introduction of the "intelligent" control mode on one of the conveyors (a haulage consisting of four conveyors, an innovation used on conveyor no. 2) resulted in an increase in the time when the active haulage is available for mining by over 5 hours.

The results of using the "intelligent" mode for longwalls are very interesting, as it is easy to determine the costs and profitability of such an investment due to the knowledge of the unit longwall standstill costs.

Table 1

Characteristics of haulage operation time in "intelligent" control mode – daily observations

Date	"Recovered" working time as a result of innovation – daily
13.03.2023	00:09:30
14.03.2023	00:06:38
15.03.2023	00:13:31
16.03.2023	00:25:56
17.03.2023	00:06:49
18.03.2023	00:00:00
19.03.2023	00:00:00
Sum [hh:mm:ss]	**01:02:24**

Table 2

Characteristics of haulage operation time in "intelligent" control mode – weekly observations

Date of reading	"Recovered" working time as a result of innovation – weekly
05.03.2023	01:13:47
12.03.2023	01:43:14
19.03.2023	01:02:24
26.03.2023	01:03:53
Sum [hh:mm:ss]	**05:03:18**

Fig. 4. Excavated material presence sensor installation location

Table 3

Effects of the Elsap-05 system in intelligent mode, delivery from the 3/VII/385 longwall area in the period from November 1–12, 2023

Conveyor	Working time with "intelligent" control mode	Working time with "intelligent" control mode + mining machine is working
PT2	00:55:34	00:10:36
PT3	00:35:13	00:00:07
PT4	00:32:26	00:00:23
SUM [hh:mm:ss]	02:03:13	**00:11:06**

The above data fully justify the use of the innovative control mode on all types of haulages of excavating material in underground mining plants.

4. CONCLUSIONS

To sum up – the most important benefits of the "intelligent" control mode concept in the process of controlling mined haulage are:

- extension of the availability time of active haulage,
- reduction of lost revenues,
- extending the life of machines by reducing the number of starts.

The example of the modernization of the conveyor control systems at LW "Bogdanka" mine proves that an innovative approach to solving issues related to increasing efficiency in mining does not have to be associated with high costs. There is still a lot of potential to be exploited in the devices and systems currently used in our plants, we just need to notice where it is hidden.

References

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