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MEANING OF KNOWLEDGE TO THE INCREASED EFFECTIVENESS OF THE USE OF MINING MACHINES

Abstract. Knowledge is the key resource of every enterprise. It also applies to the mining industry. Managers of mining enterprises concentrate the activities mainly on the technical aspects while knowledge gaining and management are often neglected. The paper presents an example of using tacit knowledge to identify the causes of the breaks in chosen mining machines' work. It shows the analysis of the structure of these breaks and their division into groups. The main goal of the analysis was to develop the methodology of using tacit knowledge to increase the effectiveness of the mining machines.

Keywords: knowledge, effectiveness, mining machines, breaks in machines' work

ZNACZENIE WIEDZY DLA POPRAWY EFEKTYWNOŚCI WYKORZYSTANIA MASZYN GÓRNICZYCH

Streszczenie. Wiedza jest kluczowym zasobem każdego przedsiębiorstwa, co odnosi się również do branży górniczej. Kierownicy przedsiębiorstw górniczych koncentrują swoje działania głównie na aspektach technicznych, podczas gdy pozyskiwanie i zarządzanie wiedzą jest często zaniedbywane. W artykule zaprezentowano przykład wykorzystania wiedzy ukrytej do identyfikacji przyczyn przerw w pracy wybranych maszyn górniczych. Przedstawiono również analizę struktury tych przerw oraz ich podział na grupy. Głównym celem tej analizy było opracowanie metodyki wykorzystania wiedzy ukrytej do poprawy efektywności pracy maszyn górniczych.

Słowa kluczowe: wiedza, efektywność, maszyny górnicze, przerwy w pracy maszyn

1. Introduction

In recent years, the meaning of knowledge, as one of the basic resources necessary for the functioning and development of enterprises, has significantly grown. Knowledge is strongly connected with people who are the key resource in all kinds of business. It is obvious that material resources, especially technical means, are crucial for production companies. However, without the right approach, management and knowledge on these resources, it would be almost impossible for the organization to achieve success. People and their skills, knowledge, ideas, involvement, motivation and creativity allow other types of resources, such as finances, materials, information, to be used in a better way. It is worth emphasizing that there are different types of knowledge, and for managers it is very important to make the best use of these resources. Knowledge is also crucial for mining companies. In an increasingly competitive energy market, knowledge resources can determine the survival and economic effectiveness of these enterprises.

The article focuses on using dispatchers' knowledge in mining to identify breaks and their causes, in the machines' work. For this purpose, industrial automation systems and expert interviews were used. It turned out that to determine the reasons for the machines' breaks, it is necessary to gain tacit knowledge from the mining workers. The obtained results have great potential to be used for improving the effectiveness of the machines. The article also explains the basic terms related to knowledge and defines tacit and explicit knowledge.

2. Concepts related to knowledge

To define knowledge, firstly, what data and information mean should be considered. On surface, it seems that data, information and knowledge are similar and can be used interchangeably. In fact, they are completely different concepts. On the basis of literature analyses, a number of definitions of these concepts can be presented. Data is only a part, an element of information. It is a raw fact, a number and an event which have not been subjected to any analysis[1]. When data is subjected to human thought activities, such as observations or analyses to understand its essence, it becomes information[2]. Thus, data presented in a given context is information[3]. When information is understood, enriched with judgment and used in

[1] Grudzewski W.M., Hejduk I.K.: Zarządzanie wiedzą w przedsiębiorstwach. Difin, Warszawa 2004.
[2] Galland F.J.: Dictionary of Computing. John Wiley & Sons, Chichester 1982.
[3] Skyrme D.J.: Knowledge Networking, Creating the Collaborative Enterprise. Butterworth Heinemann, Oxford 1999.

an action, it becomes knowledge[4]. In other words, when information is used in a specific context, organized and selected, it turns into knowledge[5]. According to P. Drucker, neither labor, nor capital, nor land are so important to the organization as knowledge. In addition, the author emphasizes that knowledge is a mean of production which has a strategic meaning[6].

Analyzing the literature, it can be noticed that knowledge can be divided into four basic categories[7]:

- know-what – it refers to facts, terms, courses of action. Thus, it is knowledge on what is wanted, what is endeavored, what the current state is,
- know-why – it includes cause and effect relations about why some actions are performed, what their goals are, what they try to achieve,
- know-who – it refers to a person or people who "possess" know-what, know-why, know-how, and therefore, they are proper for the job,
- know-how – it is related to practical knowledge about how to accomplish a very thing and what kind of resources are needed. Know-how is particularly important in the production process. It refers to experience, skill and it is the basis of the practical action.

Due to the fact that knowledge is a very broad concept and includes many issues, there are many divisions of it in the literature. For example, T. Czapla and M. Malarski[8] divide knowledge in detail. Firstly, they indicate market knowledge which includes phenomena occurring in the external environment and affecting the functioning of the enterprise. Considering the interiors of an enterprise, there is structural knowledge. It refers to the structure of the organization, internal relations, relationships, interactions and connections. In addition, the authors indicate technical and technological knowledge. Technical knowledge is related to the construction of organizational resources, technical issues and functions of resources, as well as the limits of the technical resources. Technological knowledge consists of the possibilities and opportunities of using resources, and the functioning of these resources. In addition, knowledge directly related to people should not be forgotten. It is called psychosocial knowledge and it is connected with human activities in groups, relations between people in the organization, their behaviors and other elements in the human sphere. The last type of knowledge is management knowledge, which is about ways and practices of managing that are meant to help in the proper use of resources under specific market conditions. However, there is one more concept related to knowledge. When someone has the ability to make sensible and proper decisions or actions in a given situation, then we talk

[4] Jemielniak D., Koźmiński A.K.: Zarządzanie wiedzą. Wydawnictwa Akademickie i Profesjonalne, Warszawa 2008.
[5] Galland F.J.: Dictionary of Computing…, op.cit.
[6] Drucker P.F.: Społeczeństwo pokapitalistyczne. Wydawnictwo Naukowe PWN, Warszawa 1999, s. 22.
[7] Kowalczyk A., Nogalski B.: Zarządzanie wiedzą. Koncepcje i narzędzia. Difin, Warszawa 2007, s. 23.
[8] Czapla T., Malarski M.: Metody zarządzania relacjami w procesie kształtowania kapitału społecznego organizacji, [w:] Błaszczyk W. (red.): Metody organizacji i zarządzania. Kształtowanie relacji organizacyjnych. Wydawnictwo Naukowe PWN, Warszawa 2005.

about wisdom. Wisdom refers to the solving of problems in an ethical way based on a particular system of values[9]. Figure 1 shows the relations between data, information, knowledge and wisdom. These concepts form a pyramid, whose basis is data, and at the top is wisdom.

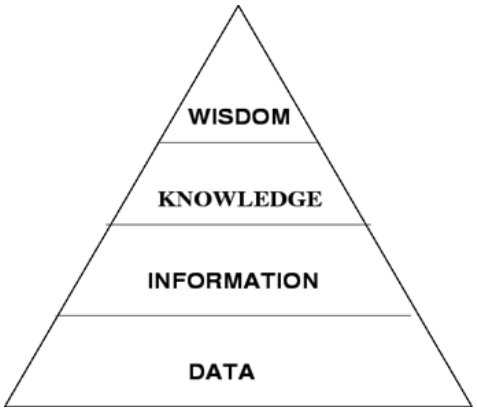

Fig. 1. The relations between data information, knowledge and wisdom
Source: Stecuła K., Brodny J.: Generating knowledge about the downtime of the machines in the example of mining enterprise. "Proceedings of 17th International Multidisciplinary Scientific GeoConferences SGEM 2017", Vol. 17, No. 13, 2017, p. 359.

3. Explicit or tacit knowledge?

There are more divisions in the literature than those described in the second chapter. One of the most groundbreaking division of knowledge is made by I. Nonaka and H. Takeuchi[10]. It indicates two types of knowledge. The first kind is explicit knowledge. It is related to the education of a specific person, it can be easily transferred, expressed with words, signs, symbols, numbers, graphs, etc. Therefore, it is expressed with formal language, systematized and specified. It can also be communicated and transferred in a clear and understandable way. It is easy to write this knowledge down, pass it on to the other person, share and gain it. Explicit knowledge can be written on physical media. This type of knowledge dominates in the Western philosophical tradition[11].

[9] Jashapara A.: Zarządzanie wiedzą. Zintegrowane podejście. Polskie Wydawnictwo Ekonomiczne, Warszawa 2006.
[10] Nonaka I., Takeuchi H.: Kreowanie wiedzy w organizacji. Jak spółki japońskie dynamizują procesy innowacyjne. Poltext, Warszawa 2000.
[11] Błaszczyk W. (red.): Metody organizacji i zarządzania. Kształtowanie relacji organizacyjnych. Wydawnictwo Naukowe PWN, Warszawa 2005.

A more complicated term is tacit knowledge. It is not directly visible or expressive. It is individualized and difficult to put into words, and because of this, it is difficult to transfer to another person. It is rooted in the mind of a specific person. Very often it comes from the experience of the very worker. It often happens that people with such knowledge do not realize that they own it. They do some things, make some activities, make some decisions based on the tacit knowledge. However, everything they do comes from their nature. It is natural for them to behave in a certain way. It is involved with the intuition, individual experiences, beliefs and imagination of the employees. They act in a given way, despite the fact that they are unable to fully explain why. And this is exactly tacit knowledge[12, 13]. As M. Polanyi rightly points out "we know more than we can tell"[14]. In addition, the author bases the concept of tacit knowledge on three following theses:

- true discovery cannot be based on articulated rules or algorithms,
- knowledge is public but at the same time, to a very great extent is personal,
- all knowledge is tacit or rooted in tacit knowledge.

Mentioning the knowledge hierarchy, data, information, knowledge and wisdom can be more closely associated with other terms. Figure 2 shows the hierarchy of knowledge in a broader sense than Figure 1. Analyzing the definition and type of knowledge, M. Kłak notices the difference between the mentioned concepts. Information and data can be turned into explicit knowledge by using technology or IT tools. However, in this case it is impossible to talk about tacit knowledge because it is related to the human factor. It is rooted in people. Human knowledge creates the intellectual capital of the organization. Therefore, we can talk about the key, unique and most valuable tacit knowledge only at the level of knowledge and wisdom (in the hierarchy of knowledge).

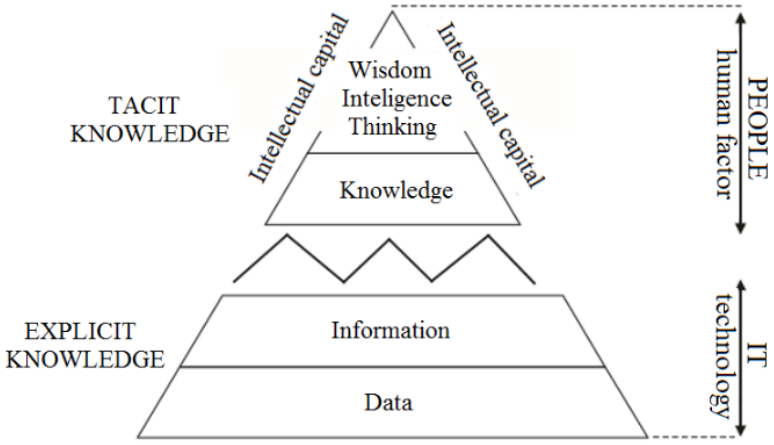

Fig. 2. The hierarchy of knowledge
Source: Kłak M.: Zarządzanie wiedzą we współczesnym przedsiębiorstwie. Wydawnictwo Wyższej Szkoły Ekonomii i Prawa im. Prof. Edwarda Lipińskiego w Kielcach, Kielce 2010.

[12] Kisielnicki J.: Zarządzanie organizacją. Oficyna Wydawnicza Wyższej Szkoły Handlu i Prawa im. Ryszarda Łazarskiego, Warszawa 2005.
[13] Nonaka I., Takeuchi H.: Kreowanie wiedzy w organizacji…, op.cit.
[14] Polanyi M.: Personal Knowledge. Towards a Post-Critical Philosophy. Harper, New York 1962.

Conducting deliberations on explicit and tacit knowledge, the conversion of knowledge should be mentioned. Conversion is a creation of the interaction between these types of knowledge. I. Nonaki and H. Takeuchi distinguish four types of knowledge conversion, including socialization, externalization, combination and internalization (Figure 3)[15].

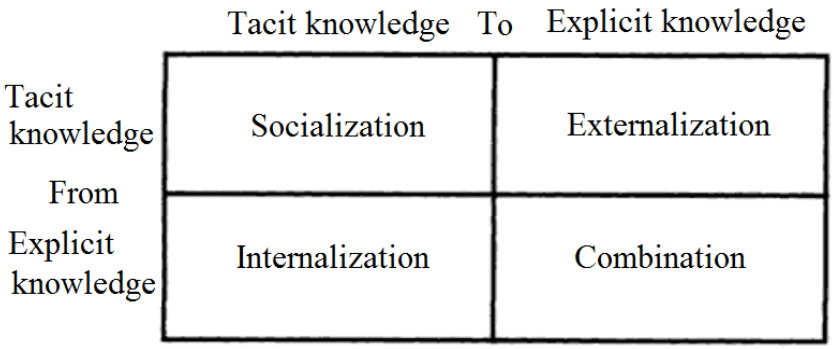

Fig. 3. The knowledge conversion processes
Source: Nonaka I., Takeuchi H.: Kreowanie wiedzy w organizacji. Jak spółki japońskie dynamizują procesy innowacyjne. Poltext, Warszawa 2000; Stecuła K., Brodny J.: Generating knowledge about the downtime of the machines in the example of mining enterprise. "Proceedings of 17th International Multidisciplinary Scientific GeoConferences SGEM 2017", Vol. 17, No. 13, 2017, p. 359.

When one person transfers tacit knowledge to another, then we talk about socialization. A person with tacit knowledge shares the experience and teaches another person who tries to imitate and observe the first person, and directly learn from her or him. Socialization is a master-student or a teacher-student relationship. Externalization is the expression of tacit knowledge with definitions or terms. Then, attempts to articulate or write down this knowledge rooted in man are made using symbols, models, metaphors or analogies. Based on the externalization, new knowledge is generated mainly thanks to the interpersonal interactions. Another type of codification is combination. At this stage, the resources of explicit knowledge grow because their new elements are being combined with already existing elements. The last kind is internalization which is aimed at attaching explicit knowledge to the tacit one. The effect of such activity is increased tacit knowledge.

On the basis of such considerations, it can be stated that tacit knowledge is a very valuable resource. It is individual, unique and based on a specific person's own experiences. However, explicit knowledge is also very important because it is formalized and necessary for functioning within the organization. Therefore, companies must take care of both types of knowledge and make the conversion of the mentioned types because, as the result, knowledge resource grows.

[15] Nonaka I., Takeuchi H.: Kreowanie wiedzy w organizacji…, op.cit.

4. Knowledge and the increased effectiveness of the mining machines

Polish coal mining faces many problems. High labor costs, low coal price, poor work organization and use of human capital, ineffective mining equipment utilization and negative opinions on the environmental matter of mining make the economic situation of the mining sector in Poland increasingly worse. In addition, the social issue is not very optimistic. One way to solve some mining problems is to consciously use knowledge resources. The article presents an example of the use of the mining workers' tacit knowledge to identify the reasons for breaks in the selected mining machines' work.

The first stage of this process was to record the work parameters of the studied machines. The research included the selected machines within the mechanized longwall system. These machines are used for coal mining and play a key role in the coal production process. The results of the preliminary study confirmed the unsatisfactory level of these machines' effectiveness, despite the fact that their technical parameters and reliability are a the very high level. The study revealed that during the machines' work, there are many unpredictable breaks whose lengths are different. The number and duration of these breaks were determined on the basis of the data obtained from the industrial automation system which continuously registers the work parameters. This registration guarantees an objective way of the breaks identification, independent of the subjective feelings of the dispatchers. The next step in the research was to determine the reasons for the recorded breaks. Due to the fact that the automation system is not able to find these reasons, other actions have been taken. They referred directly to the employees responsible for recording breaks and their causes.

Based on numerous discussions, meetings and interviews with the dispatchers who write these breaks down, it appeared that the causes of breaks are in most cases known. However, this knowledge was in the category of tacit knowledge. The employees kept this knowledge only for themselves because of the specific interpersonal relationships at the mine. Therefore, the reasons for the lack of registration of most of machines' breaks were: improper work atmosphere, fear of management and its actions after revealing the real reasons for the low effectiveness of some machines. Thus, it was the bad atmosphere, poor relations between employees and managers, not knowing the workers, the low level of human resources management, lack of motivation, communication, awareness of the employees' role and lack of sense of belonging to the mine that resulted in an unwillingness to reveal important information. Then, the actions were taken to make dispatchers aware how important it is to share their knowledge on the causes of the breaks. In addition, some facilities in breaks registration were implemented. The IT tool has been developed to make registration easy, fast, convenient, trouble-free and user-friendly. In addition, the dispatchers could report the problems in an anonymous way. The application of the tool led to a significant increase in the effectiveness of identifying the causes of the breaks.

In order to confirm the efficiency of the developed and applied methodology, Figure 4 shows an example of the structure of the breaks during the longwall shearer's work. Data presented in this figure includes the four weeks of the longwall shearer's work (60 work shifts). The structure consisted of the six categories. For each of them, the overall number of the unplanned downtimes during the shearer's work and the number of the breaks, whose reasons were found, were shown. The percentage relation of the identified reasons to the overall number of the registered breaks was also presented. Moreover, Table 1 shows the times of the unplanned breaks based on the duration in the studied longwall shearer's work.

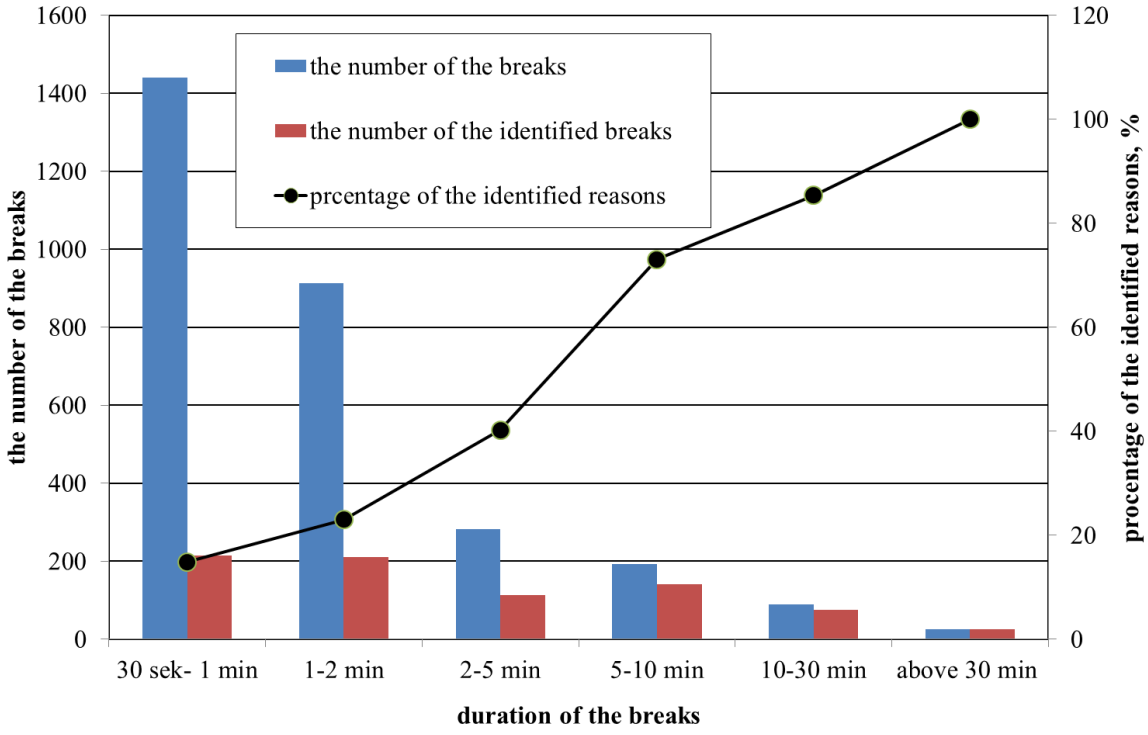

Fig. 4. The structure of the breaks in the longwall shearer's work
Source: own work.

Table 1

The time of the unplanned breaks based on the duration in the longwall shearer's work

	30 sec-1 min	1-2 min	2-5 min	5-10 min	10-30 min	over 30 min
The total time of the breaks, min	1292	1520	1171	1404	1862	1290
The total time of the breaks, whose causes were found, min	186	365	461	1098	1643	1290

Source: own study.

By analyzing the data, it can be seen that the shortest intervals (1-2 minutes) formed the largest group according to the number of the breaks as well as their total duration. It should be emphasized that the longer the breaks are, the smaller their number is. The figure also shows the percentage of the downtimes, whose causes were determined using the IT tool. It turned out that the disclosure of tacit knowledge made it possible to identify generally all breaks whose duration was more than 30 minutes. Thus, it can be assumed that the developed methodology and the conducted research justified the validity of the assumptions. The results are very satisfactory.

The registration of the reasons for the breaks also made it possible to divide the causes into groups. There are five basic categories of the causes which include mining, mechanical, electrical and hydraulic reasons, as well as a category with breaks whose causes were not found. Figure 5 shows the mentioned division taking into account the durations of the breaks in the studied longwall shearer's work.

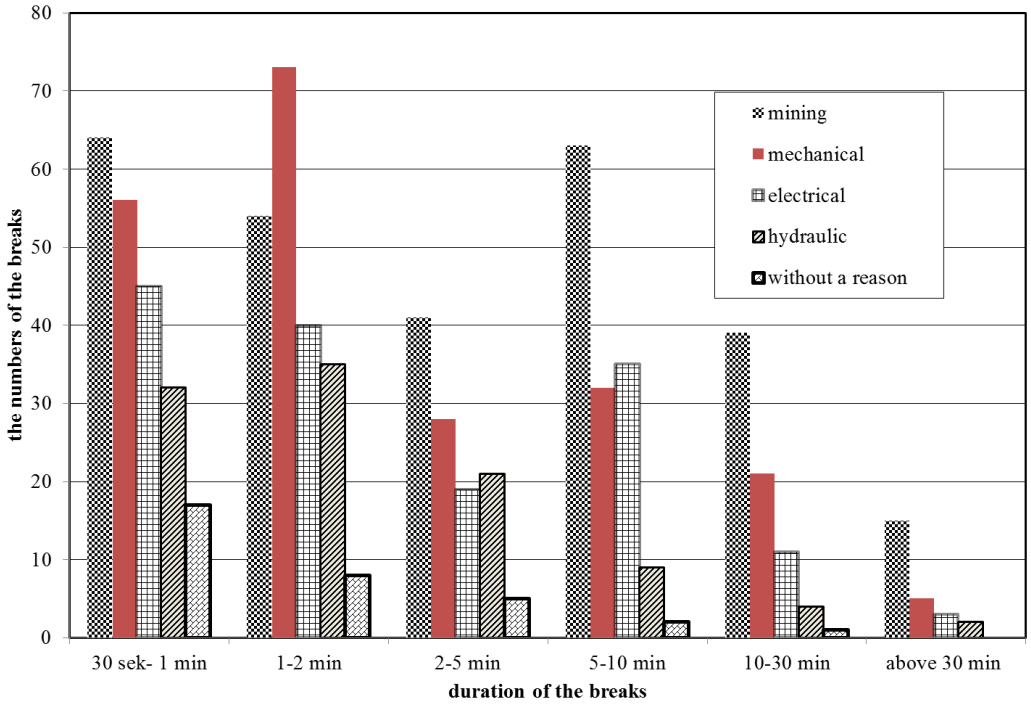

Fig. 5. The reasons for the breaks in the longwall shearer's work
Source: own work.

The conducted analysis of the causes of the breaks in the shearer's work and the obtained results allow the development of the necessary actions and taking decisions to reduce or eliminate the downtimes. Knowledge on the real causes should significantly improve the effectiveness of the reparation actions.

The downtimes reduction should improve the availability and, at a later stage, the effectiveness of the machines. An increase in the effectiveness of the machines' use, in turn, should result in increased economic effectiveness of the entire mine. Therefore, it can be

stated that the taken actions allowed disclosing some of tacit knowledge on problems and causes of the downtimes. Tacit knowledge turned out to be essential in the mine's internal problems. The research has confirmed that knowledge is very important for functioning of the company. The enterprises, especially the coal mines, should make great effort to gain this knowledge as quickly as possible, and then to use it effectively.

5. Conclusions

The article presents an example of using knowledge of the workers in the coal mine. This knowledge concerned the causes of the breaks occurring during the mining machinery's work. At the mine, the information tool was used to register the reasons for the breaks by the mining workers. This tool made it possible to use tacit knowledge of the dispatchers in a better way.

The implementation of the tool made it possible to find almost 27% of the numbers of reasons for the breaks recorded by the industrial automation system. In the range of duration of these breaks, it was possible to describe almost 60% of the total duration of the unplanned breaks in the longwall shearer's work.

Better results were obtained in terms of the breaks whose duration were over 5 minutes. The reasons for 79% of the downtimes were described. In reference to the overall duration of the breaks, 88,5% of the causes were found. The obtained results should be positively evaluated, especially in the context of previously used methods. These methods determined a maximum of 25-30% of the unplanned downtimes. Therefore, it can be assumed that application of the IT tools combined with proper workers motivation made it possible to efficiently reveal the tacit knowledge in the area of identification of the reasons for the unplanned breaks during the longwall shearer's work.

Determining the causes of the specific breaks will help to develop actions that will be taken to eliminate at least some of these breaks. In turn, the reduction of the breaks will mean increased effectiveness of the mining machinery, especially in the area of their availability. The developed system aimed at only gaining information about the real causes of the downtimes. However, in practice, it is necessary to introduce a motivational system for employees and convince managers to apply this system.

The obtained results instill optimism about the further activities aimed at gaining knowledge about exploitation and effectiveness of the mining machines.

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