Analysis of Mining Accident Levels against the Background of Changes in Productivity and Employment in the Hard Coal Mining Industry

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Abstract

Occupational safety is an extremely important area of concern in every company. In mining companies, it occupies a particularly high position in the hierarchy of tasks and objectives. An accident at work is defined as a sudden event, caused by an external cause, resulting in injury or death of a worker and which occurred in connection with work. An accidental event consists of a number of interrelated adverse technical, organisational, environmental and human events. However, it is recognised that human error (interference) is usually the initiating factor of an accident at work. Among the causes of errors can be distinguished primarily: human failure, characteristics of the tasks performed, the conditions of the physical environment and the impact of the social environment, technical conditions. Therefore, within the framework of accident prevention, apart from the technical sphere, attention is also paid to the sphere of management – motivation, proper training, information flow, as well as assessment of psychophysical features of employees and their adaptation to the workplace. It is even more justified in the situation, where as it results from many years' data of the Central Statistical Office (GUS), the so-called human factor is responsible for about 60% of accidents at work in Poland. The level of accidents can be analysed from several angles. Interesting is correlation of level of accidents from factors, which have influence on management. Then it is possible by controlling these elements to influence the number of accidents at work. It is especially important in such branch as mining, in which according to GUS data the highest number of accidents was registered in Poland. Intuitively, most causes of accidents, according to the literature, are caused by human factors. A fall in the accident rate should be a natural consequence of a reduction in the workforce. However, a reduction in employment must not result in a decrease in labour productivity. In this article, the authors present the results of a study of correlation between these three indicators: employment level, productivity and accident rate, in Polish coal mines over the period 2003–2020.

Keywords: *accidents, mining companies, productivity, employees*

1. Introduction

An accident at work is defined as a sudden event caused by an external cause resulting in injury or death to an employee and occurring in connection with work (Art. 33).

It is clear from the definition itself that an accident at work consists of four main elements (Konopka, 2021):
- the suddenness of the event,
- external cause
- relationship to work,
- injury or death as a result of the event.

It is important that these elements have to occur simultaneously for there to be a work accident.

At the same time there has been an evolution in the theory of causality of accidents at work and related OSH prevention - from accidents being seen as "the result of a deviation, which is an event, characteristic or condition that deviates from the norm that defines a proper and planned production process" (Pietrzak, 2003) to "the model of an accident as a consequence of mistakes made due to a deficit of motivation, knowledge and experience" (Studenski, 1996) of employees. Such an approach prompts us today to address, within OHS prevention, not only the technical sphere but also the organisational one and to search for correlations between other factors that build effective management (Tobór-Osadnik, Wyganowska,

2020). Since OSH is an inseparable component of the management (Flin et al., 2000) system such approach inclines to examine within the framework of accident analysis not only the technical sphere but also the sphere of human resources management (Caruth et al., 2009). It is all the more justified in the situation where, as it results from many years' data of the Central Statistical Office (GUS), the so-called human factor is responsible for about 60% of accidents at work in Poland (Wyganowska, Tobór-Osadnik, 2014). According to GUS, in 2020 the highest number of accidents was recorded in the mining and quarrying section (https://stat.gov.pl/). An accident event consists of a series of interrelated adverse technical, organizational, environmental and human events (Studenski, 1999). It is recognized, however, that human error (disturbance) is usually the initiating factor of an accident at work. Among the causes of errors, we can distinguish primarily: human failure, characteristics of the tasks performed, conditions of the physical environment and the influence of the social environment, the first of which is very much related to the age or length of service of the employee. For many years, restructured companies in the mining sector have been striving to reduce the number of people employed, seeing in this an opportunity to quickly reduce fixed production costs. It can therefore be assumed that as the number of employees falls, the number of accidents at work should also fall.
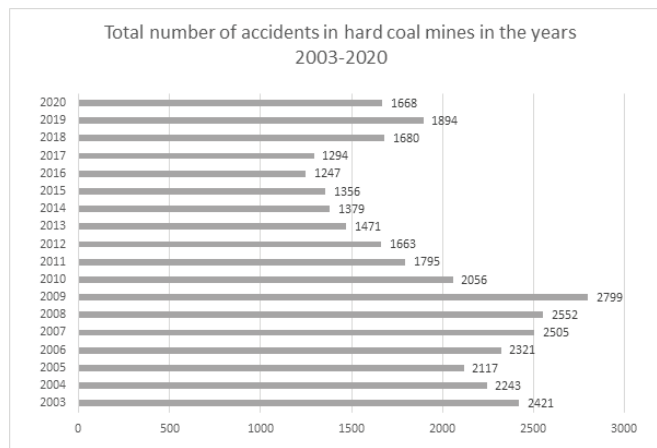
Rys. 1. Liczba wypadków w pracy w kopalniach węgla kamiennego w latach 2003–2020 (dane statystyczne WUG)
Fig. 1. Total number of accidents in hard coal mines in the years 2003–2020 (statistical data WUG)
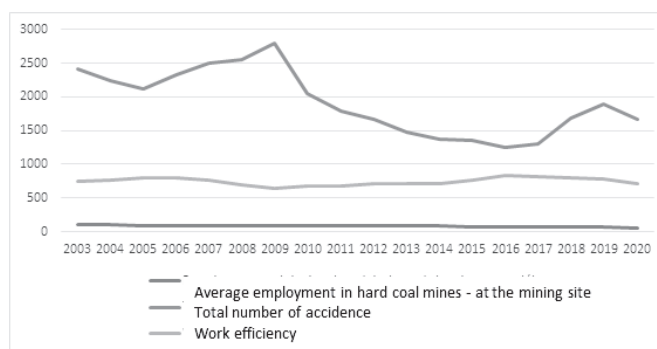
Rys. 2. Zmiany w poziomie zatrudnienia, wypadkowości i wydajności pracy w kopalniach węgla kamiennego w latach 2003–2020
Fig. 2. Changes in employment, accidents and efficiency of workers in hard coal mines in the years 2003–2020

2. Methodology

Is this the case for the mining industry? This was one of the main questions of the analysis conducted. The second question to which an answer was sought: Do changes in worker productivity levels translate into occupational accident rates. It can be assumed that an increase in productivity may lead to a greater number of errors leading to accidents, because the employee, in the pursuit of convenience or improved productivity, may try to bypass or disable the safety measures in place at the workplace, which in turn may also increase the accident rate (Pietrzak, 2007). The authors pointed out the other side of this situation. With proper occupational health and safety management, actions improving work efficiency should go hand in hand with occupational safety and widely understood prevention in this area.

The authors used correlation analysis to analyze the data. As it is known, this analysis in statistics consists of examining whether two variables are statistically significantly related to each other. However, not only the correlation coefficient is important, but also the researcher's inference (Donovan et al., 2014). Very important in correlation analysis is the fact that it does not examine the cause-effect relationship, but simply the relationship and co-occurrence of two variables (Śleszyński, 2020).

Correlation (interdependence of characteristics) determines the interrelationship between selected variables. Positive correlation (the value of the correlation coefficient from 0 to 1) – indicates that the increase of one attribute is accom-

panied by the increase of average values of the other attribute, negative correlation (the value of the correlation coefficient from -1 to 0) – indicates that the increase of one attribute is accompanied by the decrease of average values of the other attribute (Hyk, Stojek, 2019).

The analysis presented in the publication was based on statistical data on the number of employees and accidents in mining companies in 2003–2020. The publication presents results of the analysis of correlation between productivity and changes in the number of employees and the number of accidents at work.

3. Investigating the relationship between employment, productivity and accidents in coal mines

The relationship between productivity, changes in employment and the number of accidents in hard coal mines was examined using Pearson's linear correlation coefficient. As mentioned earlier, this coefficient is used to examine rectilinear relationships of the variables under study, in which an increase in the value of one of the traits causes proportional changes in the average values of the other trait (increase or decrease). A weak correlation or lack of it occurs at values below 0.2.

As presented in figure 1 in the analysis of accidents recorded in mining companies between 2003 and 2020, it is difficult to clearly identify the dominant trend. It is only since 2009 that a downward trend can be observed, only to record an increase in accidents again in 2017. Interestingly, in 2009 there was an increase in the total number of accidents at min-
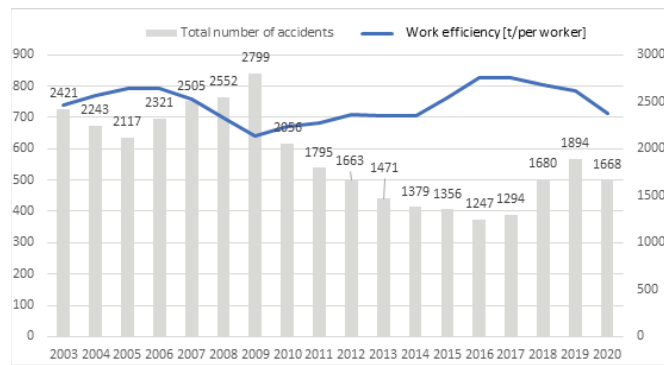
Rys. 3. Zmiana wydajności w korelacji do liczby wypadków w koaplniach węgla kamiennego w latach 2003–2020
Fig. 3. Changes in efficiency against the number of accidents in hard coal mines in the years 2003–2020
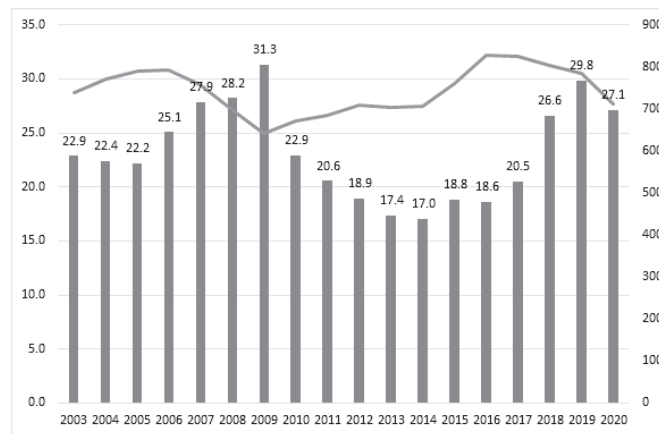
Rys. 4. Wydajność pracy [t/osoba] w korelacji do poziomu wypadkowości w kopalniach węgla kamiennego w latach 2003–2020
Fig. 4. Employee efficiency [t/per worker] against accident rate in hard coal mines in years 2003–2020

ing companies, which coincides with very high staff turnover in the previous year. According to statistics, almost 14,000 people were made redundant in the mining industry in 2008, while more than 17,200 new employees were hired (statistical data ARP).

Large fluctuations in the number of accidents at work can be observed between 2003 and 2020. Decreases in the number of persons employed were more regular - from an employment level of 105 800 persons in 2003 to 61 500 persons in 2020. However, the decrease of more than 44,000 people is not clearly reflected in the number of occupational accidents in coal mines.

The changes in the number of accidents and labour efficiency presented in Figure 3 throughout the analyzed period appear to be completely independent and uncorrelated. This is also what emerges from the study of correlation relationships. A coefficient of -0.34 was calculated (Table 1), which indicates a weak negative correlation relationship between the number of accidents and labour productivity over the period 2003–2020. A negative relationship means that when the values of one variable (productivity) increase, the values of the other variable (number of accidents) decrease.
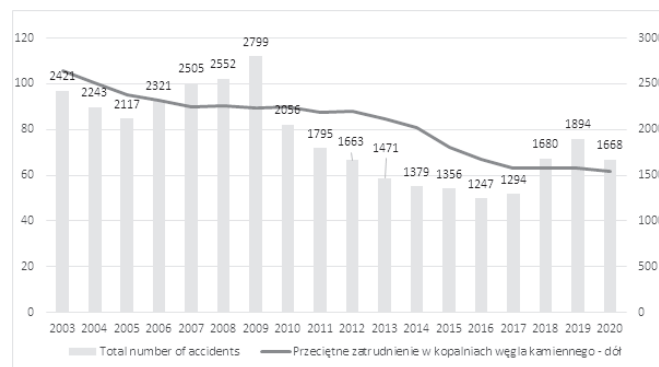
The calculated correlation coefficient indicates a high correlation relation between the number of persons employed in hard coal mines in 2003–2020 and the number of accidents – 0.68. A positive result indicates that as the number of persons employed decreases, the number of accidents also decreases. However, a deeper analysis of the data presented in Table 1

shows some deviations from this relationship. For example, in 2018 there was an increase in employment by only 100 people (0.16%) and in the number of accidents by 386, i.e. by almost 30% compared to 2017. The courses of changes in both quantities in the years 2003–2020 are illustrated in Figure 4.

4. Summary

Human errors that may lead to accidents at work often occur in situations of mismatch between the requirements set by the employer and the workers' capabilities. One such requirement may be high productivity or an expected rapid increase in productivity. This can lead to a quantitative overload of workers, which in the chain of events leads to an accident situation. Often such a situation is a consequence of dysfunctions of the existing management system, including human resources in the enterprise. Therefore, activities leading to the desired increase in productivity, which are carried out inappropriately, may create difficult situations and, consequently, accidents. It can be noted that accidents are also symptoms of inadequacy of the workplace to the assumed tasks or to the conditions in which the assumed objectives are to be achieved. A consequence of this assumption is the idea of accident prevention, which involves preventing accidents by initiating actions and creating solutions to increase the company's ability to eliminate such causes of accidents. It is therefore worth examining the correlation between selected quantities and the number of accidents at work in order to define possible inadequacies. With the above assumptions in

Year	Average employment in hard coal mines - at the mining site [thousands]	Total number of accidents	Work efficiency [t/per worker]
2003	105,8	2421	739
2004	100,2	2243	771
2005	95,3	2117	791
2006	92,6	2321	793
2007	89,9	2505	758
2008	90,4	2552	698
2009	89,4	2799	641
2010	89,8	2056	671
2011	87,3	1795	684
2012	87,8	1663	710
2013	84,7	1471	704
2014	80,9	1379	706
2015	72,1	1356	761
2016	66,9	1247	827
2017	63,0	1294	825
2018	63,1	1680	804
2019	63,3	1894	784
2020	61,5	1668	712
CORRELATION FACTOR	0,68		-0,34

Rys. 5. Zmiany poziomu zatrudnienia w korelacji do liczby wypadków w kopalniach węgla kamiennego w latach 2003–2020

Fig. 5. Changes in the average employment against the number of accidents in hard coal mines in the years 2003–2020

mind, the authors analyzed in the presented publication the correlation between the number of accidents at work and productivity and the level of employment, so that, on the basis of the research carried out, they could draw conclusions and create pro-efficiency system solutions in the field of safe work in this area.

To summarize – the number of accidents at work decreases with a fall in the number of employees, but there is no cor-relation between the number of accidents and productivity. Changes in productivity, whether increases or decreases, do not translate into decreases or increases in the number of accidents in hard coal mines over the 18-year period analyzed. These phenomena are very positive and may indicate that the process of staff reduction and increase of work efficiency is being properly implemented from the point of view of safety systems.

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Analiza poziomu wypadkowości w górnictwie na tle zmian wydajności i zatrudnienia w górnictwie węgla kamiennego

Bezpieczeństwo pracy jest niezwykle istotnym obszarem troski w każdym przedsiębiorstwie. W przedsiębiorstwach wydobywczych zajmuje wyjątkowo wysoka pozycję w hierarchii zadań i celów. Wypadek przy pracy definiuje się jako zdarzenie nagłe, wywołane przyczyną zewnętrzną, powodujące uraz lub śmierć pracownika, a które nastąpiło w związku z pracą. Na zdarzenie wypadkowe składa się wiele powiązanych ze sobą niekorzystnych zdarzeń technicznych, organizacyjnych, środowiskowych i ludzkich. Uznaje się jednak, że zazwyczaj czynnikiem inicjującym wypadek przy pracy jest błąd (zakłócenie) człowieka. Pośród przyczyn popełniania błędów można wyróżnić przede wszystkim: niesprawność człowieka, cechy realizowanych zadań, warunki fizycznego środowiska oraz wpływ środowiska społecznego, uwarunkowania techniczne. Dlatego w ramach profilaktyki wypadkowości oprócz sfery technicznej zwraca się uwagę również na sferę zarządzania – motywację, prawidłowe szkolenie, przepływ informacji, a także ocena cech psychofizycznych pracowników i ich dopasowania do stanowiska pracy. Jest to tym bardziej uzasadnione w sytuacji, gdzie jak wynika z wieloletnich danych GUS, za około 60% wypadków przy pracy w Polsce odpowiedzialny jest tzw. czynnik ludzki. Poziom wypadkowości można rozpatrywać w kilku ujęciach. Interesująca jest korelacja poziomu wypadkowości od czynników, na które ma wpływ kieownictwo. Wtedy można sterując tymi elementami wpływać na liczbę wypadków przy pracy. Jest to szczególnie ważne w takiej branży jak górnictwo, w którym według danych GUS odnotowano ich najwięcej w Polsce. Intuicyjnie naturalnym następstwem zmniejszenia zatrudnienia powinien być spadek poziomu wypadkowości. Jednakże zmniejszenie stanu zatrudnienia nie może powodować spadku wydajności pracy. W artykule autorki zaprezentowały wyniki badania korelacji między tymi trzema wskaźnikami: poziomem zatrudnienia, wydajnością i wypadkowością, w polskich kopalniach węgla kamiennego na przestrzeni lat 2003–2020.

Słowa kluczowe: *wypadki, kopalnie, wydajność, pracownicy*