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## THE INFLUENCE OF EFFECTIVE WORK TIME ON AN EMPLOYMENT LEVEL IN A COLLIERY – CASE STUDY

**Summary.** In the paper the author discussed issues concerning the determinants of effective work time and its influence on an employment level in hard coal mining. An employment level and its structure are among key factors determining work productivity in a colliery. The study was undertaken in a selected Polish colliery, based upon source materials and direct interviews with the managerial staff. The results of undertaken research were estimated changes of an employment level in a selected colliery due to changes in technical parameters increasing effective work time. The analysis was done making use of the IT tool, System Supporting Employment Level Planning in a Colliery, elaborated in the Institute of Management and Administration of Silesian University of Technology. The author also recommended possible actions in a long term resulting in increasing effective work time, and finally in improving work productivity in an analysed colliery.

**Keywords:** work performance, effective work time, employment level, colliery.

## WPLYW EFEKTYWNEGO CZASU PRACY NA POZIOM ZATRUDNIENIA W KOPALNI WĘGLA KAMIENNEGO – STUDIUM PRZYPADKU

**Streszczenie.** W artykule autor podjął dyskusję na temat czynników determinujących efektywny czas pracy i jego wpływu na poziom zatrudnienia w górnictwie węgla kamiennego. Poziom zatrudnienia oraz jego struktura stanowią główne czynniki determinujące wydajność pracy w kopalni węgla kamiennego. Badania, które zostały przeprowadzone w wybranej polskiej kopalni węgla kamiennego, zostały oparte na analizie materiałów źródłowych oraz wywiadach bezpośrednich z kadrą menedżerską wytypowanej kopalni. W efekcie przeprowadzonych badań zostały ustalone zmiany w poziomie zatrudnienia analizowanej kopalni w wyniku optymalizacji parametrów technicznych, zwiększającej wykorzystanie efektywnego czasu pracy. Analiza poziomu

zatrudnienia została przeprowadzona z wykorzystaniem narzędzia informacyjnego SWPPZKWK (Systemu Wspomagania Planowania Poziomu Zatrudnienia w Kopalni Węgla Kamiennego), opracowanego w Instytucie Zarządzania i Administracji Politechniki Śląskiej. Dodatkowo w artykule autor przedstawił rekomendacje możliwych działań długoterminowych, które mogą doprowadzić do zwiększenia efektywnego czasu pracy górników, co umożliwi osiągnięcie poprawy wydajności pracy w analizowanej kopalni węgla kamiennego.

**Słowa kluczowe:** wydajność pracy, efektywny czas pracy, poziom zatrudnienia, kopalnia węgla kamiennego.

## 1. Introduction

Currently, the observed problems of Polish hard coal mining sector are linked to a radical reduction in coal prices in recent years. The ARA<sup>1</sup> price of coal fell from 129.50 USD/t on 01.07.2011 to 48.33 USD/t on 07.01.2016 i.e. by 62.7% over five years. Restructuring changes, mainly in the area of technical and technological restructuring<sup>2</sup> and downsizing led to a profitable activity of Polish coal companies in the years of 2008-2012. Nowadays further actions are necessary in order to adapt coal companies to the changing internal and external conditions of functioning<sup>3</sup>. The key to a long-term perspective will be reducing the unit production cost of coal and increasing work performance in production plants of coal companies.

The required actions, undertaken by coal companies' board of directors, should be aimed at more effective human resources management to improve work productivity<sup>4</sup> taking into account the employment level allowing economically effective and safe realisation of technological and business processes in operating collieries. A very important issue for improving productivity level in coal mines is the optimal balance of employment and the increase of effective work time of employed miners and external firms<sup>5</sup>.

In this article the author presented the results of the study concerning effective work time and work productivity in a chosen colliery. On the base of source materials and direct

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<sup>1</sup> [http://gornictwo.wnp.pl/notowania/ceny\\_wegla/archiwum/25.html](http://gornictwo.wnp.pl/notowania/ceny_wegla/archiwum/25.html).

<sup>2</sup> Gumiński A.: Model planowania poziomu zatrudnienia w kopalni węgla kamiennego i w grupie kopalń. T.1. Wydawnictwo Politechniki Śląskiej, Gliwice 2010, s. 211.

<sup>3</sup> Jonek-Kowalska I.: Challenges for long-term industry restructuring in the Upper Silesian Coal Basin: What has Polish coal mining achieved and failed from a twenty-year perspective? "Resources Policy", No. 44(2015), p. 135-149.

<sup>4</sup> Gumiński A., Karbownik A., Wodarski K.: Analiza zmian wskaźników technicznych, ekonomicznych i finansowych w polskim górnictwie węgla kamiennego w latach 1990-2006. „Wiadomości Górnicze”, nr 1, 2008, s. 2-13; Klank M.: The determinants in the development of coal mining sector productivity (Uwarunkowania w kształtowaniu wydajności pracy branży węglowej). „Arch. Min. Sci.”, Vol. 56 (2011), No. 3, p. 507-516.

<sup>5</sup> Karbownik A., Gumiński A.: Zakres i skala procesów technologicznych realizowanych przez firmy zewnętrzne w kopalniach węgla kamiennego. „Przegląd Górniczy”, nr 9, 2011, s. 65-69.

interviews with engineering and technical staff of a colliery, the analysis was undertaken to get the parameters determining the employment level and to establish the possibilities of increasing of effective work time of miners as a result of reducing a total absence indicator and limiting losses of work time. Finally, the analysis was done to determine the influence of the increase of effective work time on the employment level of chosen departments in an analysed colliery. The possible employment reduction was determined which would result in higher work performance in different units and totally in a colliery. The analysis was done making use of the information system SSEL<sup>6</sup> (System Supporting Employment Level Planning in a Colliery), elaborated in the Institute of Management and Administration of Silesian University of Technology. Additionally, the undertaken study enables to determine necessary actions in the range of potential possibilities of increasing effective work time of employees in the long-term perspective.

## **2. The analysis of factors and conditions determining effective work time in a colliery**

Effective human resources management is mainly a decisive factor resulting in the high level of work productivity. The most important processes involved in human resources management in a colliery are as follows:

- planning the level and structure of employment in a colliery taking into account the coal production output, technical infrastructure and applied technical and technological solutions,
- planning the level and structure of employment of external firms' employees supporting the activity of a colliery,
- effective management of work time<sup>7</sup> which significantly affects the level of work productivity<sup>8</sup>,
- creating pro-effective work environment,
- active actions in the range of human resources development.

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<sup>6</sup> Gumiński A.: Zastosowanie systemu informatycznego SWPZZ w zarządzaniu zasobami ludzkimi w kopalni węgla kamiennego. Zeszyty Naukowe Politechniki Śląskiej, s. Organizacja i Zarządzanie, z. 60, Gliwice 2012, s. 97-113.

<sup>7</sup> Gumiński A.: Efektywny czas pracy zatrudnionych w kopalni węgla kamiennego. „Przegląd Górniczy”, nr 9, 2010, s. 104-107; Gumiński A.: Czynniki obniżające efektywny czas pracy zatrudnionych w kopalni węgla kamiennego. Zeszyty Naukowe Politechniki Śląskiej, s. Organizacja i Zarządzanie, z. 56, Gliwice 2011, s. 89-104.

<sup>8</sup> A. Gumiński: Czynniki decydujące o wydajności pracy w wybranych kopalniach węgla kamiennego. „Wiadomości Górnicze”, nr 10, 2012, s. 562-567.

The key process in each colliery to achieve high level of work productivity is effective planning the employment level and its structure and to get high productivity of machinery in production processes in a colliery.

The productivity of colliery's system depends on the performances of resources involved in technological processes. The production system of a colliery includes a lot of technological processes<sup>9</sup> which require to ensure the proper coordination of resources, in terms of their quantity and quality for effective realisation of these processes. The key point is the optimal quantitative and qualitative structure in all organisational units<sup>10</sup> of a colliery and also an effective work time use of involved human resources. Taking into consideration the activity of a colliery, the following factors are decisive for the reduction of effective work time:

- the absence of underground and surface workers,
- time to get to and return from workplace,
- reduced work time due to difficult climatic conditions,
- removal of breakdown processes.

Analysing workers' absence in a colliery, it is necessary to take into account the following its sources:

- tariff leave,
- disease leave,
- additional leave for underground workers,
- health and healing leave,
- so called "Z-days" as a result of working on free Saturdays and Sundays,
- training and courses,
- periodic examinations,
- free days for trade unions' workers,
- secondment,
- blood donation,
- childcare for the age up to 14 years' children,
- occasional leave,
- toll-free leave,
- unjustified absences.

Losses of time due to harmful or difficult work conditions are connected with obligatory shortened work time from 7,5 hours to 5,5 hours in some underground workplaces in a colliery, mainly in productive longwalls and driven workings.

Losses of work time connected with the time to get to and return from workplace derive from a far distance of longwalls or driven working from the shaft, disadvantageous technical

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<sup>9</sup> Gumiński A.: Analiza pracochłonności procesów technologicznych realizowanych w ścianie wydobywczej w kopalni węgla kamiennego, [w:] Karbownik A. (red.): Czynniki kształtujące elementy systemu zarządzania współczesną organizacją. Gliwice 2008, s. 81-90.

<sup>10</sup> Armstrong M.: Zarządzanie zasobami ludzkimi. Oficyna Ekonomiczna, Kraków 2000.

solutions of transportation roads, and the necessity of the pedestrian movement of mining crew as well.

Losses of time connected with the removal of breakdown processes derive from the necessity of removal of disruptions or defects and the restoration of the workplace or the device to normal functioning. The frequency of breakdown processes and labour consumption associated with its disposal determines the level of work time losses in a colliery.

### **3. The possibility analysis of the increase of effective work time and its influence on the employment level in a selected colliery**

In the range of undertaken study the following issues were analysed:

- the analysis of the structure of the total absence indicator of underground and surface workers in an analysed colliery – on the base of source materials,
- the determination of technical parameters characterising the activity of a colliery on 31.12.2015 – on the base of interviews with engineering and technical staff of a colliery,
- the determination of possible changes in decreasing the level of total absence rate of underground and surface workers – on the base of interviews with engineering and technical staff of a colliery,
- the estimation of the range of increasing of effective work time of workers realising primary and supportive processes in running longwalls – on the base of interviews with engineering and technical staff of a colliery,
- the calculation of the employment level in an analysed colliery on the base of technical parameters,
- the calculation of the employment level in an analysed colliery taking into account the changes of technical parameters as a result of increasing effective work time,
- the proposal of recommendations in the range of actions enabling the increase of effective work time in an analysed colliery in the long-term perspective.

Table 1

## The structure of the total absence rate in an analysed colliery in 2015

No.	Workers' group	Diseases	Trainings	Other excused	Unexcused	Tariff leaves	Additional leaves	Absence	Free days for Saturdays, Sundays and holidays	Total absence
1.	Underground workers	7,12%	0,96%	2,48%	0,11%	11,61%	1,80%	<b>24,08%</b>	1,59%	<b>25,67%</b>
2.	Surface workers	5,90%	0,69%	3,63%	0,06%	10,07%	0,00%	<b>20,35%</b>	1,09%	<b>21,44%</b>
3.	<b>Total in a colliery</b>	6,91%	0,92%	2,68%	0,10%	11,34%	1,48%	<b>23,42%</b>	1,50%	<b>24,93%</b>

Source: Own study.

In table 1 the values of total absence rate in an analysed colliery are given. It is worth mentioning the very low value of a unexcused absence rate (only 0,11% for underground workers and 0,06% for surface workers). The actions concerning the reduction of the absence rate should be concentrated on lowering the disease rate.

In the range of undertaken study the employment level in an analysed colliery was calculated, and the changes in the employment level taking into account the reduction of a total absence rate for underground and surface workers and the reduction of the number of production shifts and maintenance shifts in running longwalls was estimated. The calculation was done by making use of the information system SSELP (System Supporting Employment Level Planning in a Colliery), elaborated in the Institute of Management and Administration of Silesian University of Technology, which was based on the model of employment level planning. SSELP enables in the long-term perspective the prognosis of the target level and structure of employment in a colliery and in the group of collieries on the basis of information characterizing the existing colliery's infrastructure, geological and mining conditions of coal production, as well as the size and concentration of exploitation and coal processing parameters.

System Supporting Employment Level Planning allows the following analyses<sup>11</sup>:

- forecasting the employment level in the organizational units of a colliery and the group of collieries based on technical and organizational parameters characterising these collieries,
- estimating the employment changes due to different scenarios of restructuring in a colliery or the group of collieries,

<sup>11</sup> Gumiński A.: Zastosowanie systemu informatycznego SWPZZ w zarządzaniu zasobami ludzkimi w kopalni węgla kamiennego. Zeszyty Naukowe Politechniki Śląskiej, s. Organizacja i Zarządzanie, z. 60, Gliwice 2012, s. 97-113..

- the determination of necessary planning decisions concerning the allocation of workers in the framework of an individual colliery or within the group of collieries,
- the analysis of the employment balance in organizational units of an individual colliery or within the group of collieries based on forecasts of staff needs and the forecast of necessary changes in staff, which allows to specify the scale and timetable of necessary recruitment and dismissal of workers,
- preparing in advance any data for recruitment and selection of candidates or the necessary redundancies, displacement and retraining,
- obtaining information about staff's fluctuations in organizational units of a colliery in the long-term perspective,
- limiting the surplus or deficit of employment in individual organizational units of a colliery to increase the level of making use of work time of employees, which results in reducing labour costs,
- the possibility to adapt employment plans to changing parameters and conditions, i.e. to anticipate in advance the actions responding expected changes.

Table 2

Key technical parameters determining technological processes  
in an analysed colliery on 31.12.2015.

No.	Parameters' names	Unit	Parameter's value
1.	Average daily net output	[t/d]	11 514,0
2.	The number of longwalls with caving		2,8
3.	The number of longwalls with filling		0,0
4.	The number of workings driven by a cutter loader		7,0
5.	The number of workings driven by explosives		0,0
6.	The number of output shafts		2,0
7.	The number of ventilating shafts		2,0
8.	The number of countershafts		1,0
9.	Total length of underground workings	[m]	251 439,0
10.	Total length of main belt haulage	[m]	25 448,0
11.	The number of main belt haulage drives		64,0
12.	Total length of division belt haulage	[m]	4 900,0
13.	The number of division belt haulage drives from longwalls	[m]	4,0
14.	The number of division belt haulage drives from working ends		36,0
15.	Total length of an underground railway	[m]	26 500,0
16.	Total length of ceiling narrow-gauge railway	[m]	48 600,0
17.	Total length of floor narrow-gauge railway	[m]	4 200,0
18.	The number of reinforces longwalls in a year		3,0
19.	The number of liquidated longwalls in a year		2,0
20.	The rate of absence of underground workers	[%]	25,67
21.	The rate of absence of surface workers	[%]	21,44

Source: Own study

The key technical parameters determining technological processes in an analysed colliery were given in table 2. After discussions with engineering and technical staff of a colliery it was decided that both the total absence rate for underground workers and surface workers could be reduced to 5% in all production plants of a coal company, which included an analysed colliery. As a result, in an analysed colliery, the value of the total absence rate for underground workers was established at 23,55% (the decrease of 2,12%), and the value of the total absence rate for surface workers was established at 20,54% (the decrease of 0,90%).

The calculation of the employment level was done taking into consideration the changes in work organisation and the decrease of losses of work time to get to and return from workplace. The basic assumption was the 7,5-hour-shift for a miner in a colliery due to the Polish regulations.

In table 3 the possible changes in the decrease of the number of shifts in an analysed colliery were given. These changes take into account the decrease of the time to get to and return from workplace. Making use of belt conveyor for transportation of workers and organization changes enables the decrease of the total time to get to and return from workplace from 160 minutes (i.e. 90 minutes to get to workplace and 70 minutes to return from workplace) down to 55 minutes (taking into consideration the fact that all analysed longwalls were located in the same exploitation field).

Table 3

The reduction of longwalls' shifts in an analysed colliery taking into account the decrease of time to get to and return from workplace

No.		The number of production shifts before change	The number of maintenance shifts after change	The time to get to workplace and the return before change	The time to get to workplace and the return after change	The necessary work time of a production shift	The necessary work time of a maintenance shift	The number of production shifts after change	The number of maintenance shifts after change
1.	Longwall A	3,80	1,00	160,00	55,00	1102,00	290,00	2,83	0,75
2.	Longwall B	4,10	1,00	160,00	55,00	1189,00	290,00	3,06	0,75
3.	Longwall C	2,80	1,00	160,00	55,00	812,00	290,00	2,09	0,75

Source: own study.

The important assumption in the calculation was the constant daily net coal output in analysed longwalls, despite large reserves of coal production. The calculations of employment levels were done for 31.12.2015 based on technical parameters characterising production processes in an analysed colliery (given in table 2). Additionally, taking into consideration above-mentioned assumptions, the calculation of the changes in an employment level were done based on the changes of the values of technical parameters determining labour



consumption of technological processes as a result of the reduction of a total absence rate and the decrease of the number of productive shifts and maintenance shifts in running longwalls.

The calculation results of the employment level and its reduction in selected organisational of an analysed colliery units were given in table 4.

Table 4

The potential employment reduction in an analysed colliery taking into account the increase of effective work time

No.	Organisational unit	Initial values	End values	The change
1.	Director's department	51	51	0
2.	Mining department	1 502	1 386	-116
3.	Ventilation department	365	357	-8
4.	Coal processing department	423	420	-3
5.	Energy-mechanical department	1 865	1 782	-83
6.	Technical department	4 373	4 161	-212
7.	Human resources and economics director's department	100	100	0
8.	Total colliery	4 524	4 312	-212
9.	Net total work performance [kg/wd]	2 545	2 670	125
10.	Work performance per one employee [t/y/w]	641	673	32

Source: Own study.

The possible reduction of an employment level in an analysed colliery is the result of the increase of effective work time. The significant changes were achieved in Mining Department – the reduction of 116 employees and in Energy-mechanical Department – the reduction of 83 employees. Totally, in an analysed colliery the achieved reduction in the level of employment was from the level of 4 524 employees down to 4 312 employees, i.e. about 212 employees reduction. The increase in total work productivity was from the level of 2 545 kg/wd up to 2 670 kg/wd, i.e. the increase of 25 kg/wd (assuming the constant value of an average daily net coal output of 11 514 t/d). The annual productivity per employee was calculated assuming 252 working days per a calendar year. There was the increase in the productivity per employee from the level of 641 t/y/w up to 673 t/y/w, i.e. the increase of 32 t/y/w.

#### **4. Recommendations for actions increasing effective work time in a colliery in the long term perspective**

In mid-term and long-term perspectives the key aspect for the activity of a colliery is the increase of work productivity through the more effective use of human resources, including the higher level of effective work time of employed underground and surface workers. To

achieve higher effectiveness of the use of work time in a colliery the following actions should be undertaken:

- the optimization of the employment structure in order to best adapting to the ongoing functions and responsibilities,
- the further work reorganization in order to eliminate unnecessary processes and activities and the elimination of redundant work positions.
- the development of central and group air conditioning in order to reduce time losses resulting from the difficult and harmful work conditions in longwalls and driven working,
- the development of transportation systems for miners in order to reduce the time to get to and return from workplace,
- the reduction of the total work absence rate, mainly disease absence, and permanent monitoring of work absence, especially the control of long-term disease leaves,
- the professional development of employees by raising skills, and acquiring additional qualifications, in accordance with the model of combined professional qualifications,
- shaping the employment age and probation structure in a colliery (the adequate recruitment of young and well-educated and professionally prepared employees).
- the introduction of multiple activities of miners, which means training employees to get the combined professional qualifications (e.g. energy-mechanical and mining qualifications, hydraulic and mining qualifications, mining and electrical qualifications, mechanical and mining qualifications). This solution could improve work organization, and also reduce time losses deriving from interruptions and breakdowns of machinery and equipment.

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## Omówienie

W artykule autor podjął badania dotyczące czynników determinujących efektywny czas pracy i jego wpływu na poziom zatrudnienia w górnictwie węgla kamiennego. Poziom zatrudnienia oraz jego struktura stanowią główne czynniki determinujące wydajność pracy w kopalni węgla kamiennego. Badania, które zostały przeprowadzone w wybranej polskiej kopalni węgla kamiennego zostały oparte na analizie materiałów źródłowych oraz na wywiadach bezpośrednich z kadrą menedżerską wytypowanej kopalni.

W efekcie przeprowadzonych badań zostały ustalone zmiany w poziomie zatrudnienia analizowanej kopalni w wyniku optymalizacji parametrów technicznych, zwiększającej wykorzystanie efektywnego czasu pracy. Analiza poziomu zatrudnienia została przeprowadzona z wykorzystaniem narzędzia informatycznego SWPPZKWK (Systemu Wspomagania Planowania Poziomu Zatrudnienia w Kopalni Węgla Kamiennego), opracowanego w Instytucie Zarządzania i Administracji Politechniki Śląskiej.

Dodatkowo w artykule autor przedstawił rekomendacje możliwych działań w perspektywie długoterminowej, które mogą doprowadzić do zwiększenia efektywnego czasu pracy górników, co umożliwi osiągnięcie poprawy wydajności pracy w analizowanej kopalni węgla kamiennego.