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EXTENSION OF LONGWALL'S EFFECTIVE WORKING TIME

3.1 INTRODUCTION

The environment in which companies operate is constantly undergoing changes that determine their growth and even survival [5]. Bengtsson and Kock characterized the essence of cooperation stating that competitive cooperation in today's economy seems to be a relation of companies' highest developing potential [3]. Thus, possibilities of overcoming and/or limiting the environmental barriers' influence should be looked for within inter organizational relations [7]. What seems to be an interesting solution is implementation of the case study methodology. The main reason would be the fact that the network theory is in early stage of development and the case study in management studies is used for extensive diagnosis of a studied phenomenon [4]. A created research tool, used for diagnosis of inter organizational relations of a company, should include questions concerning areas like: partners choice, formalization, mutual influence and involvement, cooperation motivation, its benefits and dangers. Therefore it is worth to concentrate not on a single relation between companies but a whole network of a given company's connections in order to fully understand the influence of those correlations on its functioning.

3.2 CHARACTERISTICS OF A MODERN COMPANY

The need to ensure profitability of the coal mining industry and to adapt it into the competitive market of energy resources requires Polish coal mining industry to be adjusted to reality of market economy. It requires changes both technical and organizational and, as a consequence, it forces employment limitations, liquidation of unprofitable mining facilities and restructuring of redundant unproductive assets [8, 11, 14, 15]. Therefore the "Modern Company" is characterized by its technology, economy, market and management.

TECHNOLOGY – introduction of modern machinery, adaptation to ecology requirements.
ECONOMY – calculation of cost and effect, constant calculation of effectiveness, confrontation of actions and expenditures, relation of cost and effect. Optimization of decisions according to effectiveness criteria, accumulation of assets in general.

MARKET – liberalism, free functioning supply and demand market mechanism and marketing as actions adapting a company to external determinants.

MANAGEMENT – oriented towards effective use of assets, machines, human and financial

assets. Implementation of modern devices and effective group management [6, 9].

Therefore, limitation of mining company's costs became a managing priority for the Polish coal mining sector. To realize the main goal which is a mining company's effectiveness, rules must be set in order to limit its costs [6, 8, 11].

3.3 LIMITATION OF COSTS

Technical restructuring of mining facilities requires setting goals which result in so called output concentration consisting in lengthening panel lengths to about 2 thousand meters, lengthening longwalls to about 300 meters and longwall output of 5 thousand Mg/d. This technical goal can be achieved with special attention directed towards:

- providing high reliability of longwall and other technical equipment,
- increasing productivity of machinery which requires their power increase,
- providing sufficient speed of preparatory works adjusted to required progress of a longwall front,
- effectiveness improvement by decrease of culm amount and thus increase of thick output assortment,
- improvement of mining cleanness, especially concerning thin layers which decreases costs of mechanical coal processing and transport,
- improvement of layer demethanization systems in order to achieve daily output,
- layer management leading to achievement of a technical goal.

Effectiveness of a properly designed mechanization system depends heavily on output concentration and limitation of costs. The latter may be divided into two groups: working costs and production costs. Costs are a company's strategic element which must constantly be adjusted to market rules. During realization of a given project (exploitation of a longwall) the highest budget concerns the following assets:

- human (work at a longwall),
- material (equipment purchase or lease cost, its working costs),
- financial (costs of spent capital),
- informative (evaluation, documentation).

The material assets element is a part of a project costs which currently has the biggest influence on the mining facility's productivity and thus it should be limited. To achieve this goal, work organization should be improved in order to maximize the daily utilization of machines and devices. This will lead to increase of a project's productivity and therefore will create possibilities for company's dynamic development.

Movement of a longwall may be hampered by external conditions (natural geological limitations e.g. CH₄, water, rockbursts) and organizational conditions. The latter form the biggest obstacle for effectiveness of our actions which we influence and create ourselves. Maximum exploitation of machines' daily working time will result in improvement of longwall's productivity. Organizational conditions hampering effectiveness and improvement of longwall's productivity can be divided into four basic groups: machines,

electricity, ventilation, mining. Extension of maximum effective daily working time of a machine results (without changes in employment policy) in increased unit profit in a ton of coal per one employee. This will lead to limitation of lost costs which means possibilities to be employed by a given longwall [1, 6, 8, 11,14, 15].

3.4 POSSIBLE WAYS OF REALIZATION

Current technological and organizational knowledge states that a longwall is able to work 24 hours a day during a five-day working week, from Monday till Friday. Improvement in work organization should be based on thorough preparation of excavation so that the goal can be achieved. Current limitations of longwall's constant working time can be eliminated by the use of machines and devices qualified for constant work. If a longwall (in a design stage) does not show any geological limitations, the only criteria to limit constant work is the choice of machines, devices and work organization. Basic limitations of longwall's constant movement may be divided into limitations concerning:

- mining – longwall drifts should be secured in advance so that it does not interfere with the longwall progress. Transportation of elements needed for exploitation should proceed on-line.
- machines – providing: media to power machinery, water and compressed air. Another problem is a longwall conveyor's rearrangement which should be executed along with longwall's front movement whereas shortening of a conveyor belt should be executed on Saturdays.
- electricity – machine power supply system should be designed to enable longwall's front movement during a five day period. Alteration of power systems should be done on days free from work e.g. Saturday.
- ventilation – preparation of longwall front demethanization technology, powering and rebuilding of ventilators influencing longwall's constant work.

All maintenance work should be executed on Saturday. Currently, most maintenance work is done on Saturdays so that it does not interfere with the mining process. The only break in the longwall shearer's work (as it is the main indicator of longwall's front movement) should be the result of technological breaks (e.g. inspection, methane measurement, replacement of cutting elements).

3.5 EFFECTS OF COST LIMITATION

This article presents average data concerning work of the mining facility and its "lost" possibilities. The study shows three longwalls of Kompania Węglowa S.A. in a period of one month. The analysis presents a degree of use of longwall shearers in a whole facility during a period of one year. A degree of shearer's use is defined as its work In one Day, starting from 6.00 (first Shift) until 5.59. The analysis presents 4 longwalls exploited within one year. The average degree of use within the analyzed period is a percentage concerning shearer's work only on working days excluding Saturdays, Sundays and holidays. To perform the analysis it was necessary to collect

data concerning working time, malfunctions of mining equipment based on the ZEFIR dispatcher system and from dispatcher systems daily reports from a period of one year. Throughout the whole analyzed year, the mining facility of Kompania Węglowa exploited 4 longwalls (the ones that began or finished their commission in that year were excluded) and the degree of use was within range of 0 to 83.33%. Daily output was in range of 0 to 7920 t/d [10, 11, 12].

Mining facility's results achieved in one month

In relation to achieved results, longwalls had 2 mining shifts, 3 mining shifts, 4 mining shifts and one maintenance shift. They also differed in effective working time [12]. Table 3.1 shows the analyzed period consisting of 20 working days, daily output was different each day and the average was 9452.5 tons. The average unit price was 261.79 zł and the economic sales result reached 2476485.36 zł.

Table 3.1 Daily output, price per Mg, economic sales result

No [Day]	Output netto in [Mg/day]	Unit price [zł/Mg]	Economic sales result [zł]
Monthly amount	189050	5235.93	49529707.3
Daily average	9452.5	261.79	2476485.36

Source: [12]

Table 3.2 shows that during the analysed period average daily stoppages caused by malfunctions and the effective shearers' daily working time was different depending on geological conditions and the systems' failure frequency. Table 3.2 shows possible shearers' daily working time without malfunctions which reaches 55.67% of a day, real 45.18% and daily stoppages caused by malfunctions which consume 10.49% of a day.

Table 3.2 Malfunction-caused daily stoppages, effective shearers' daily working time possible shearers' daily working time without malfunctions

No [Day]		Malfunction-caused daily stoppages		Effective shearers' daily working time		Possible shearers' daily working time without malfunctions	
		[min]	[%]	[min]	[%]	[min]	[%]
1	Sum	9065.00	209.84	39035.52	903.60	48100.52	1113.44
	Average effective working time	453.25	10.49	1951.78	45.18	2405.03	55.67

Source: [11, 12]

Possible production results and lost possibilities of the mining facility

Table 3.3 and Figure 3.1 show that within the analyzed time, average daily stoppages caused by malfunctions, with an additional shift, will rise by 3.5% of a day. Effective shearers' daily working time will rise to 15.06% a day. Table 3.3 presents possible shearers' daily working time without malfunctions which will rise to a level of 18.56% of a day. Effective, average working time of a mining unit would reach 73.23% a day with an additional shift.

Table 3.3 Malfunction-caused daily stoppages, effective shearers' daily working time possible shearers' daily working time without malfunctions depending on a number of mining shifts

	Malfunction-caused daily stoppages		Effective shearers' daily working time		Possible shearers' daily working time without malfunctions		Number of mining shifts
	[h]	[%]	[h]	[%]	[h]	[%]	
Average effective working time	2.52	10.49	10.84	45.18	13.36	55.67	3
	3.36	13.99	14.46	60.24	17.82	74.23	4
Difference	0.84	3.50	3.62	15.06	4.46	18.56	1

Source: [11, 12]

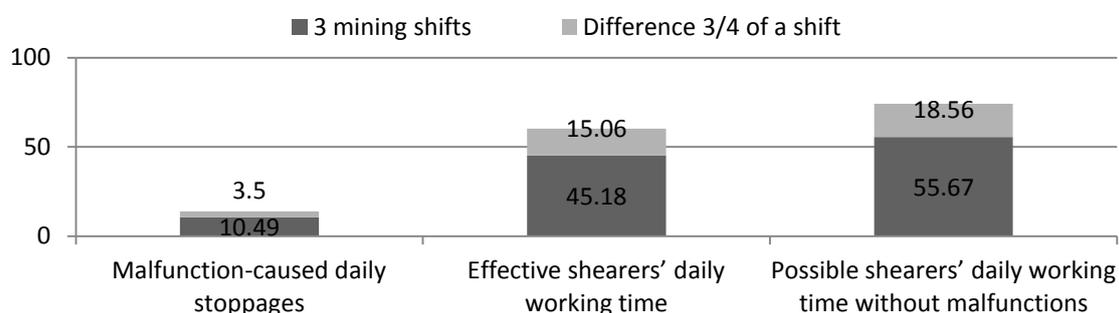


Fig. 3.1 Malfunction-caused daily stoppages, effective shearers' daily working time possible shearers' daily working time without malfunctions depending on a number of mining shifts [%]

Table 3.4, Figure 3.2 and 3.3 that, within the analyzed period, the average three and four shift output and "lost" possibilities of the mining facility reached 3150.8 Mg. The difference in the economic sales result reached 822941.2 zł/day.

Table 3.4 Daily output, economic sales result for 3 and 4 mining shifts and lost possibilities of the mining facility

Number of mining shifts	Output netto [Mg/day]	Economic sales result [zł/day]
3	9452.5	2476485.4
4	12603.3	3299426.6
„Lost” possibilities	3150.8	822941.2

Source: [12]

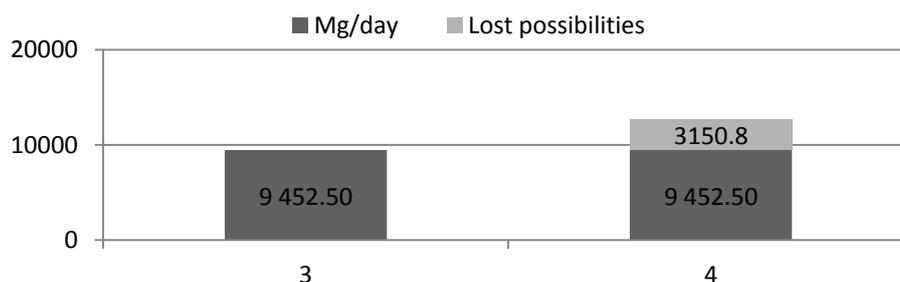


Fig. 3.2 Output netto in Mg/day depending on a number of mining shifts

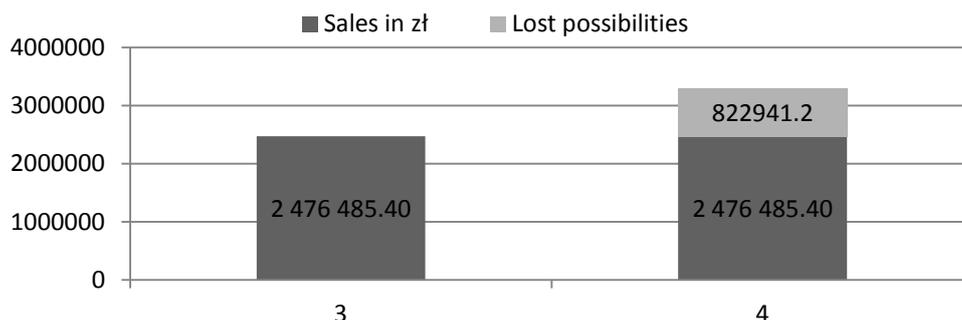


Fig. 3.3 Economic sales result in zł depending on a number of mining shifts per day

Table 3.5 and Figure 3.4 show that, within the analysed period, the average difference of monthly output with three and four mining shifts reached 63016 Mg. Lost possibilities of economic sales result were 16458824 zł.

Table 3.5 Monthly output and economic sales result for three and four mining shifts and lost possibilities of the mining facility

Number of mining shifts	Output netto [Mg/month]	Economic sales result [zł/month]
3	189050	49529708
4	252066	65988532
„Lost” possibilities	63016	16458824

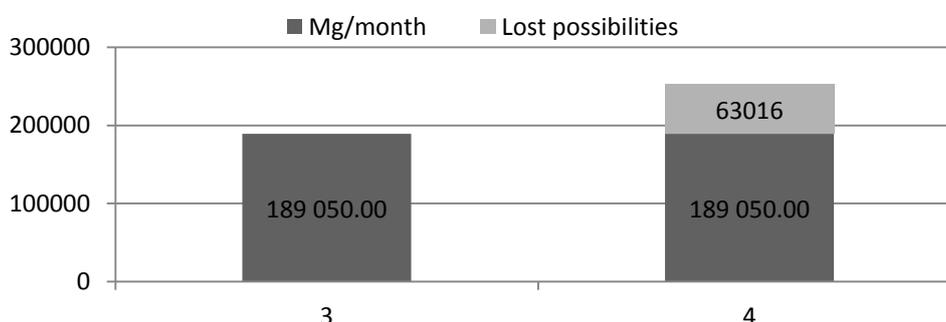


Fig. 3.4 Monthly output netto in Mg/month depending on number of mining shifts

3.6 ANNUAL MINING FACILITY PRODUCTION RESULTS

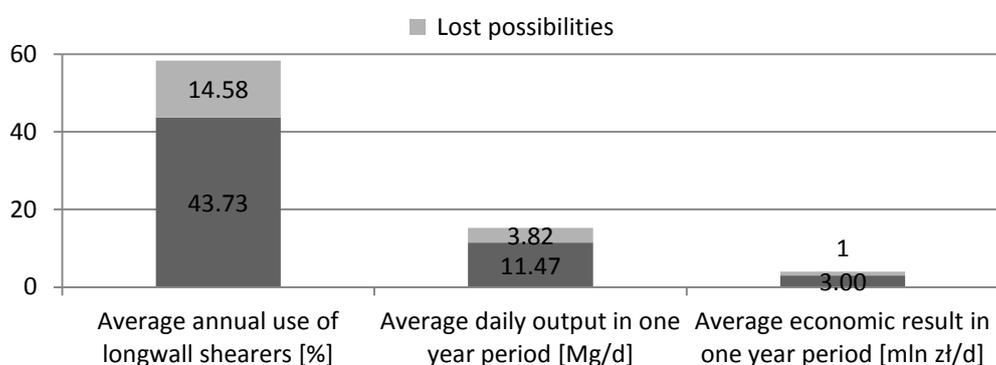
Table 3.6 and Figure 3.5 show that, within the analyzed period, the average percentage of shearers use was 43.73% and the “lost” possibilities constituted 14.58% of shearers’ working time. The average annual output reached 11470 Mg/d, losses (lost possibilities) reached 3820 Mg/d. The average economic sales result was 3002731 zł/d and lost possibilities of the mining facility were 1000910 zł/d.

The analysis was based on the ZEFIR dispatcher system which presents a degree of shearer’s use but it is not sufficiently accurate. The data from the system present only the shearer’s engaged/disengaged state and does not mention if the shearer’s work is a result of mining, idle work or the shearer’s maneuvering. More thorough analysis would be possible if it took into account the shearer’s engine workload. This would allow to exclude the shearer’s idle work or maneuvering movement.

Table 3.6 Average percentage of shearers use, daily output and economic sales result

No	Shearer	Average percentage of use within the whole longwall working period	Average daily output in one year period	Average economic result in one year period - unit price 261,79 [zł/Mg]
		[%]	[Mg/d]	[mln zł/d]
1	Joy 4LS20	34.5	2164	566513.6
2	Electra 1000/A	39.4	2724	713116.0
3	Electra 1000	56.0	4808	1258686.0
4	Eickhoff SL-300	45.0	1774	464415.5
Sum		43.7	11470	3002731.0

Source: [10]

**Fig. 3.5 Degree of shearers use, daily output, economic sales result, lost possibilities of the mining facility within one year**

Source: [10]

CONCLUSIONS

This work presents comparative analysis of a mining facility, its output, economic sales result, “lost” possibilities, malfunction-caused stoppages, shearers’ effective work and possible shearers’ working time without malfunctions depending on a number of mining shifts. As a result of constant work i.e. increasing the number of mining shifts to four will increase a degree of use of mining facility’s production capabilities which will decrease its losses and improve the facility’s economic sales result. The four-shift system makes it possible for the facility to increase its annual working time and annual output by 25% with unaltered employment system. Constant work from Monday to Friday will not lead to increase in employment of mining personnel and costs of wages since longwalls actually work in a four-shift system. The fourth, maintenance shift employs similar number of personnel to the mining shift and that is why those calculations were excluded. What will change is the number of mining staff and the wages costs as the number of personnel employed on Saturdays will slightly increase. Because of the fact that work is planned also for free days, there will not be any dramatic changes in the facility’s economic result. However, the cost of wages is not the only cost that changes when constant work system is applied. Intensification of layer exploitation is profitable because of better utilization of equipment and limita-

tion of many elements of unit costs which are part of a fixed cost. Constant work will increase mining facility's entrepreneurship and its personnel's innovative character, creativity and expansively. The constant work system will lead to a decreased number of needed longwalls, simplification of the mine's structure and limitation of investments. The financial result for a mining facility will improve although we know that higher concentration around longwalls does not automatically lead to shortening of active excavations and improvement of other works or expected limitation of mining costs [1, 8, 11]. If a mining facility takes three key factors into consideration, leadership, trust and communication, the managers' attitude towards communication between departments and concentration on long-term goals will play a crucial role in achieving success. Trust is a very important factor in technology distribution and increase of cooperation. Effective communication is connected with attitude towards different conflicts and identification of common goals [2]. Higher production concentration including introduction of additional mining shifts creates only a possibility of costs limitation and that possibility needs to be exploited [1, 8, 11].

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Abstract: *The article presents a way to increase annual output of a mining facility by 25% with unaltered employment system. The article presents comparative analysis of a mining facility, its output, economic results of sales, "lost" possibilities, stoppages due to malfunctions, effective work of longwall shearers and their predicted malfunction-free working time depending on a number of mining shifts. Implementation of constant work i.e. increasing the number of mining shifts to four per twenty four hours will allow for enhancement of a mining facility's production capabilities utilization and decrease of a mining facility's losses which will result in improvement of economic results of sales.*

Key words: *Mining facility, output, economic result, "lost" possibilities, malfunctions, effective work of longwall shearers, constant work, number of mining shifts*

WYDŁUŻENIE EFEKTYWNEGO CZASU PRACY PRZODKA ŚCIANOWEGO

Streszczenie: *W artykule przedstawiono sposób wzrostu wydobycia rocznego zakładu wydobywczego, o około 25%, przy niezmiennym systemie zatrudnienia pracowników. Przedstawiono analizę porównawczą zakładu wydobywczego, jego wielkości wydobycia, wyniku ekonomicznego ze sprzedaży, „utraczone” możliwości, przerwy spowodowane awariami, efektywną pracę kombajnów oraz możliwą pracę kombajnów bez awarii w zależności od ilości zmian wydobywczych. W wyniku zastosowania pracy ciągłej, tj. zwiększenia liczby zmian wydobywczych z produkcją na dobę, czyli zastosowanie czwartej zmiany wydobywczej umożliwi zwiększenie stopnia wykorzystania zdolności produkcyjnej zakładu wydobywczego, oraz zmniejszy straty zakładu górniczego, co poprawi wynik ekonomiczny ze sprzedaży.*

Słowa kluczowe: *Zakład górniczy, wielkość wydobycia, wynik ekonomiczny, „utraczone” możliwości, awarie, efektywna praca kombajnów, praca ciągła, ilości zmian wydobywczych*

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