



Factors Determining the Level of the Planned Concentration of Coal Production in Polish Mining

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Abstract

Restructuring processes carried out for years in the Polish hard coal mining industry have been implemented on the basis of many programs and strategies. They differed from each other in terms of scope and manner of addressing problems, but all had one goal – to reduce costs and improve operational efficiency. The aim of the article is to present selected organizational and technical factors that determine the planning of hard coal mining in a Polish mining company.

Keywords: coal mining company, restructuring process, efficiency

Introduction

Restructuring processes which have been conducted for years in Polish black coal mining were implemented based on numerous programmes and strategies. They were different in terms of the range and manner of approaching problems, but they all had one purpose – lowering the costs and improving the efficiency of functioning.

The term productivity – total or partial – is often used as an indicator for determining efficiency. The measure of partial productivity can be any indicator expressed in the form of a quotient, in which the resulting productive effect is related to the amount of the used input resources of a production system. In a black coal mine, the effect is the amount of commercial coal produced in extraction operations or the length of excavated corridor headings in accessing and preparatory operations. It is precisely within this scope that the productivity of an extraction face is evaluated, its measures being, for example [Prusek et al., 2017]:

- the number of tonnes of commercial coal extracted from one longwall – during a shift, a day,
- the number of metres of excavated corridors – by one shearer, during a shift, a day, a month.

In Polish mining, the term “concentration” has been functioning for almost a hundred years now. It was used for the first time by Professor Henryk Czeczott in 1924 in the AGH University of Science and Technology in Cracow. It addressed an assumption which should be considered when designing routes for the conveyance of extracted material – “the conveyance route should cover the largest possible area of operations, meaning that the work concentration principle should be followed” [Lisowski, 2001].

Subsequently, the term concentration was “assigned” mainly to extraction faces and over the years of the functioning of mining it evolved along with the development of the used extraction systems – with headings, shortwalls (pillars, extended shortwalls, rooms), followed by longwalls [Turek, 2010]. Due to the fact that the primary parameter related to a mine is the coal extraction rate, it began to be related to the average rate of extraction “*W*” obtained per a unit of time “*t*” (which is usually a day; it can also be a shift) from the face, which currently means virtually solely a longwall:

$$K = W / t \text{ [Mg/d]}$$

Obviously, the issue of concentrating production in a black coal mine may be considered in various aspects, e.g. the concentration of corridor excavations – the ratio of the length of corridors excavated during a day to daily coal extraction rate [Turek, 2007]. Nonetheless, considerations present in this paper will only relate to concentration whose main intended purpose is obtaining the highest possible extraction rate of a mine from the lowest possible number of walls.

However, this cannot be aimed for in a manner excluding factors connected to the specifics of the mining activity, including particularly those related to the geological-mining conditions of the position of a deposit and the occurring natural risks. This is because a high probability exists then that it would be impossible to obtain any benefits resulting from the concentration of production, and additionally, the financial expenditures paid to cut through the deposit and purchase expensive machines and devices installed in excavations would be completely unjustified.

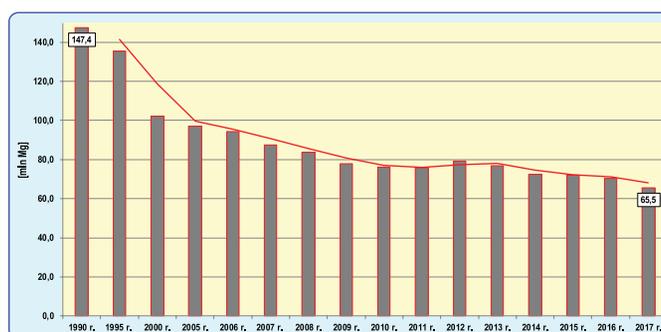


Fig. 1. Black coal extraction rates in the years 1990–2017. Source: Reports of ARP SA Department in Kato-wice.
Rys. 1. Wielkości wydobywania węgla kamiennego w latach 1990–2017



Fig. 2. Average daily extraction rates from 1 longwall in the years 1990–2017. Source: Reports of ARP SA Department in Katowice.
Rys. 2. Wielkości średniego dobowego wydobywania z 1 ściany w latach 1990–2017

The concentration of production in Polish black coal mining

In Polish black coal mining, the issue of concentrating production became particularly significant after 1990, when the implementation of changes intended to adjust it to function under the conditions of market economy began. As already mentioned, all restructuring programmes developed after this year had a single primary purpose – to lower the functioning costs of mines, including particularly the coal production cost. Lowering the cost of production may be generally achieved only by the implementation of [Lisowski, 2006]:

- organisational-savings programmes, minimising the use of labour, materials and energy,
- structural modifications leading to the simplification of mine structures and an increase in the concentration of extraction.

Experience acquired during the implementation (with various results) of restructuring programmes and strategies, which has lasted for over 25 years now, indicates clearly that it will not be possible to produce satisfactory results without simplifying the organisational and spatial structures of mines and increasing the concentration of production in extracting faces. Actions undertaken due to the awareness of this fact enabled a considerable increase in the average daily extraction rate produced from 1 longwall. Although in the years 1990–2017 the annual black coal extraction

rate dropped by over 55% – from 147.4 to 65.8 million tonnes (fig. 1), the average daily extraction rate from 1 longwall increased from 863 to 3 047 tonnes/day, meaning over 3.5 times (similar to what happened in 2006 – fig. 2).

With a specific extraction rate of a mine, obtaining satisfactory production concentration indicators may be achieved in two ways. The first one is aiming for minimising the number of extracting excavations along with the number of necessary corridor excavations – this is the so-called structural concentration. The second way is minimising labour intensity when excavating and during reinforcing, extracting and closing operations – this is the so-called operative concentration. It can be implemented by using modern machines and devices providing mechanisation or even automation of the conducted operations. In this case, all actions intended to make the mining production process more efficient and lower the costs, in a general aspect, come down to the use of production capacity, concentrated in a minimal number of faces, with a simultaneous decrease in non-productive labour intensity and in the consumption of energy and materials [Turek, 2007].

In a properly conducted planning process for the concentration of production, it is necessary to take both methods into account. In the first case, all possibilities of simplifying the structure of a mine must be initially analysed – the number of levels, accessing and preparatory excavations. This may be related either to the

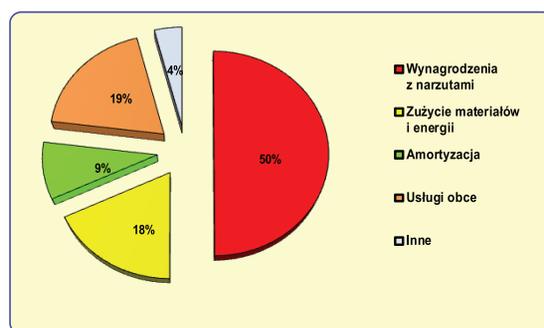


Fig. 3. The average structure of costs in black coal mining. Source: [Dubiński, Prusek, Turek 2017]
Rys. 3. Przeciętna struktura kosztów w górnictwie węgla kamiennego

elimination of expendable, already existing elements of the spatial framework of the mine, or to the creation of a new, optimal way of cutting through a deposit or seam, making it possible to design a lower number of longwalls with increased lengths and long advances (in which case the number of excavated and maintained galleries decreases as well). The next step should be the selection of proper machines and devices of mechanised complexes, including in particular:

- a powered support with a proper scope of work and bearing capacity, provided with a control system ensuring fast movement of sections,
- a winning machine (usually a shearer) with a proper towing capacity, progress rate and range of the winning parts,
- a longwall conveyor, a bottom conveyor and the ones installed along the conveyance route of the extracted material, with a proper drive construction, width, travelling speed, tensile strength.

To sum up – in a general aspect, the concentration of production in a mine is to be understood as [Turek 2007]:

- the concentration of extraction,
- improving the extraction process by decreasing the labour intensity of the whole production line, from the faces to the surface.

The concentration of production as the primary condition of decreasing extraction costs

Figure 3 presents an average structure of production costs by nature in black coal mining [Dubiński, Prusek, Turek, 2017].

Four positions comprise almost the entirety of costs: salaries with overheads (labour costs), the consumption of materials and energy, external services and depreciation. Actions undertaken in relation to aiming for an increased concentration of production have a considerable impact on lowering each of them.

Until 1990, when the introduction of changes related to the model of functioning for Polish economy

began, the topic of concentrating production in black coal mining did not have many followers. With a virtually “unlimited” demand for coal, the valid standard involved the activation of the highest possible number of extraction faces, which was supposed to ensure the acquisition of its highest possible amount. There was a concern that, in case of their frequent malfunctions, decreasing the number of extracting excavations provided with machines and devices manufactured at the time would result in a failure to complete demanding extraction plans. The situation changed under new economic conditions, when the primary priority was no longer the magnitude, but the efficiency of the conducted extraction. The necessity to lower the costs of produced coal imposed the implementation of restructuring actions, one of which involved precisely aiming for the concentration of production.

A decrease in the number of extraction faces (longwalls) resulted primarily in a considerable limitation of the length of excavated corridors (fig. 4). Apart from the fact that a lower number of longwalls directly means a lower number of longwall galleries and other galleries necessary to install devices for the conveyance of extracted material or ventilation purposes, in this case, when fully following the rules of safe mining development, further reduction is also possible, resulting from the fact that one heading may serve its functions for several longwalls. Practically, it was not feasible in a mine having 10–15 extraction faces and just as many (or more) faces of corridor operations, located usually in over a dozen areas, often very distant from each other. In a case when there are 2–4 longwalls, it is usually possible to arrange for them one heading for the conveyance of extracted material or the inflow/outflow of air. Therefore, the scope of operations related to the preparation of accessing and preparatory excavations has decreased, which affected a decrease in the costs paid by the mine in this regard. This results primarily from the significantly decreased demand for a heading support. Although headings excavated nowadays are characterised by larger cross-sections, the increase in costs paid in that regard with an overplus is

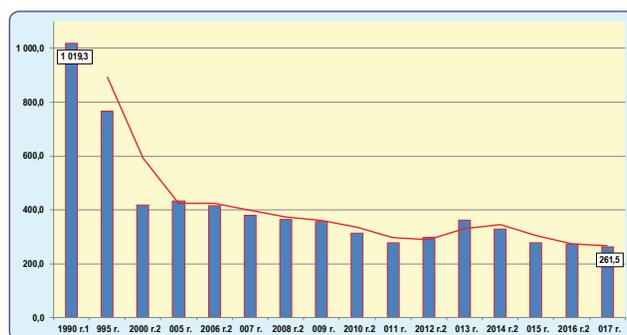


Fig. 4. The total length of corridor excavations in black coal mines. Source: Reports of ARP SA Department in Katowice
Rys. 4. Łączna długość wyrobisk korytarzowych w kopalniach węgla kamiennego

outweighed by reducing the number of metres of new headings.

Also, decreasing the number of longwalls equals a considerable reduction in the scope of operations associated with their reinforcement, and upon completing the extraction – elimination. They require considerable amounts of various materials, machines and devices, necessary for their performance, like, e.g.: routes for transporting and conveying devices, ropes, technological pipelines, various types of racks, chains, cables, conduits, electrical equipment, explosives.

The longwall extraction of a seam is possible upon providing it with the expensive devices of a mechanised complex – a powered support, a winning machine, longwall and bottom conveyors – as well as devices for the conveyance of extracted coal and the transport of materials. It is obvious that reducing the number of longwalls translates into a lower number of devices and equipment necessary to install.

And finally, the most important benefit resulting from the concentration of production – lowering the costs of labour due to the decreased number of employees necessary to perform the operations. In order to enable their safe performance, all the above-mentioned operations constituting the production process of coal – excavating, reinforcing and shutting down longwalls, extracting seams – require hiring a proper number of employees executing various activities. If, as a result of the concentration of production, the number of faces of accessing, preparatory and extracting operations is reduced, the number of hired workers also drops.

As seen above, excluding situations resulting from equipment malfunctions or exceptional occurrences due to natural hazards or unfavourable geological conditions which cause the stop-page of operations conducted in underground excavations, aiming for the highest possible concentration of production produces multiple benefits. However, is such an approach in planning the functioning of a mining facility always justified?

Factors conditioning gaining benefits resulting from the concentration of production

The proper planning of the concentration of production should take into account three basic assumptions involving geological-mining, technical and organisational issues. First of all, it is necessary to precisely identify the geological-mining conditions of the position of the extracted seam and natural hazards existing therein. Secondly – in a case when it is possible to plan the concentration of production, the selection of a proper, thoroughly mechanised extraction face – a longwall, technical equipment will be very important in terms of its efficiency. A third issue which must be carefully considered is the adoption of proper organisation of work, correlated with the position of the seam and the installed technical equipment (fig. 5).

Geological conditions for the position of a seam

When planning the level of concentration of production, the detailed identification of the geological-mining conditions of the position of a seam should involve:

- geometrical parameters – the thickness and its possible changes along the advance of the longwall, the possibility to design longwalls with long advances,
- longitudinal and transverse inclination,
- the presence of disruptions – tectonic and sedimentary – along the advance of the longwall,
- the compressive strength of roof and bottom rocks, as well as the coal mass,
- the workability of coal.

The thickness of a seam is a parameter which in a decisive manner affects the height of the designed longwall. It is obvious that better results of concentration are to be expected in thicker seams, which is due to the possibility of obtaining a higher amount of coal from a “higher” coal block won during one production cycle. In the past, the height of the longwall also conditioned the possibility to install a highly efficient mechanised complex. Currently, this is not so relevant any more, which is best evidenced by results obtained in the LW “Bogdanka” SA mine, where in four longwalls with an average height of 1.42 m, in which a planer assembly

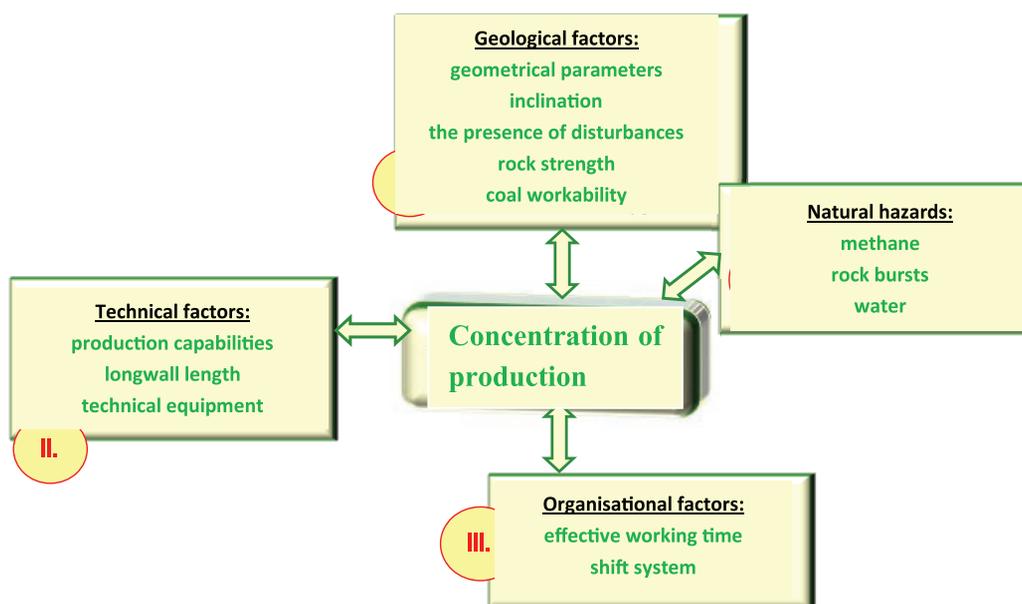


Fig. 5. Factors affecting the efficiency of the concentration of production. Source: own research
Rys. 5. Czynniki wpływające na efektywność koncentracji produkcji

was installed, the resulting daily extraction rate exceeded 10 100 tonnes [Karlikowski et al. 2016]. It is very important for the thickness of the extracted seam to be more or less uniform along the whole advance of the longwall – the presence of thickenings or thinnings may hinder the uninterrupted progress of the longwall.

In terms of the efficiency of conducting the extraction of each longwall, it is also extremely important for the position of a parcel of the seam to allow designing its longest possible advance which may be limited by the extent of the mining area, disturbances, pillars or old goafs. Operations related to the reinforcement and shutdown of longwalls are usually very time- and labour-consuming, which also makes them expensive. In order to make the costs paid because of this as low as possible, one should aim for the longest possible operation of the mechanised complex installed in the extracting excavation. The costs of reinforcing and shutting down longwalls with short and long advances are comparable, but the produced results – the amounts of coal – may differ drastically. It is assumed that if the planned extraction was to be economically sensible, the advance of a longwall with a length of 200-250 m should not be shorter than 600 m. It can be concluded that in a mine which adopts the concentration of extraction this should be no less than 1000-1200 m. In such a case, this results in the possibility to “speed up” and stabilise the production over a longer period. The correctness of such an assumption may be confirmed by the fact that the advances of longwalls in which record-breaking extraction results were produced in LW “Bogdanka” SA mine amounted to even more than five kilometres [Karlikowski et al. 2016]. Indeed, it can be concluded that in this mine it is possible because

of being allowed by the conditions of the positioning of seams. However, on the other hand, even currently in the mines of the Upper Silesian Coal Basin (GZW) longwalls with advances below 200 m are designed with their lengths amounting to 200-250 m.

The inclination of an extracted seam decides about the possibility to use devices of a mechanised complex: a powered support, a winning machine and a longwall conveyor. The vast majority of them are permitted to work with longitudinal inclinations up to 35° and transverse inclinations up to 15° towards the dip and 10° against the dip. One should remember that obtaining advantageous production results will be considerably more difficult in seams with steeper inclinations. Apart from the fact that the winning machine and conveyor will be operating with increased loads, the safety concerns of the hired crew must also be taken into account – it is more difficult to move around in the operating space and there is a risk of spontaneous rolling down of the lumps of extracted material.

Another problem to consider is the presence of tectonic or sedimentary disturbances along the advance of the planned longwall. They always lead to interfering with the normal operation of a longwall, and in extreme cases they may even prevent its progress. This has to do primarily with tectonic deformations which include faults and changes in thickness, the instances of wedging out, washing out and disappearance of a seam. It is imperative to perform a preceding identification of the existing disturbances, usually by conducting geological research or using seismic methods enabling [Turek 2010]:

- in the case of the presence of faults – estimating the magnitude of the throw, along with the determination of their courses,

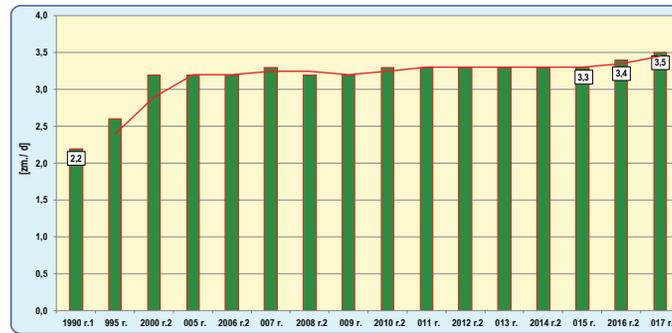


Fig. 6. Longwall production shift work in black coal mining in the years 1990–2017. Source: Reports of ARP SA Department in Katowice
Rys. 6. Zmianowość ścian z produkcją w górnictwie węgla kamiennego w latach 1990–2017

- in the case of changes in seam thickness – determining the scope and magnitude of changes.

The subsequent superimposition of complete information related to the presence of disturbances on mining maps is of key significance when planning and safely conducting mining operations.

In a geological aspect, it is also important to identify the mechanical parameters of roof and bottom rocks and workable coal mass, such as their compressive strength. In the case of weak rocks, one should take into account the possibility of the occurrence of roof falls or difficulties when progressing a section of the powered support in a soft bottom – this will also significantly affect the undisturbed performance of extraction and the safety of conducting operations. Additionally, two more issues require a careful analysis:

- the possibility to adopt fast progress of the longwall face, which is often of major significance when reducing the extent of falling weak roof rocks,
- a careful selection of resistance parameters of the powered support section – high enough to ensure a proper operation of the support, but at the same time not causing additional crushing of the layer of weak rocks during its spreading.

The knowledge of the strength parameters of the won coal mass allows the proper selection of the winning machine and determining the depth of extraction, so that no detachment of large coal lumps from sidewalls would occur during its winning. Apart from posing danger to the crew working at the longwall, this may also cause disruptions in the extraction process caused by the necessity of their fragmentation.

Another problem requiring investigation – the workability of coal – determines its susceptibility to detachment from the rock mass by means of the knives of the winning machine – the resistance which it creates against the tool disrupting its structure. Depending on the petrographic properties of coal (mineral and grain-size composition, the percentage of so-called

hard minerals), the direction of extraction, the geometry of the winning tool and on the conditions of the deposit, primarily rock mass pressure, the action of the tool results in a varying range of its crushing, breaking, chipping or fracturing.

The definition of workability encompasses various parameters characterising the resistance of coal mass when being “penetrated” by a cutting blade. The machinability index and the lateral breakage angle constitute the decisive factors. Their knowledge is critical when choosing the right type of a winning machine – a shearer or a coal planer.

The presence of natural risks is inseparably associated with the geological conditions of the position of the extracted seam. Each one of them can adversely affect the planned extraction, but special attention must be paid to three of them: methane risks, rock burst risks and water risks.

It is estimated that in the entirety of Polish black coal mining, the amount of methane released per one extracted tonne of coal equals approximately 13 m³. If the LW “Bogdanka” SA mine, which lacks methane, is excluded from the calculations, and the amounts of released methane are related only to the mines of the GZW, then this number increases up to 14 m³/Mg [http:wnp 2017]. This proves how big a problem this hazard constitutes in terms of planning and conducting extraction. Two fundamental factors contributing to its increase are: moving the extraction to increasingly greater depths and the concentration of extraction itself, implemented primarily by increasing the length of planned longwalls [Krause, Łukowicz 2012]. It is estimated that 100% more methane is emitted into a longwall with a length of 300 m compared to a longwall with a length of 200 m [http:net-tg 2010]. Due to the safety of conducting operations, these relations must be absolutely taken into account. In relation to the methane hazard, there is one more very serious limitation – the considerations of methane hazard prevention often require limiting the progress of longwall, in order to “degas” it. Such a requirement may often constitute a barrier excluding the design of extraction concentration in heavily methanic seams.

Tab. 1. The summary of factors determining the level of planned concentration of production along with an assessment of their impact
 Tab. 1. Zbiorcze zestawienie czynników determinujących poziom planowanej koncentracji produkcji wraz z określeniem ich wpływu

No.	Factor affecting the level of planned concentration	Impact
Geological factors and natural risks		
1.	The thickness of a seam, the position of the extracted parcels of a seam	Increasing / decreasing the effects of concentration by optimal / improper adoption of the height and advance of the designed longwall.
2.	Inclination of a seam	The possibility to install the most suitable machines and devices of a mechanised complex. The safety of conducting operations.
3.	The presence of disturbances	Disrupting or preventing the normal progress of a longwall. The safety of conducting operations.
4.	Strength parameters of the surrounding rocks and coal mass	
5.	Workability of coal	The efficiency of winning the coal mass.
6.	Methane hazards	The necessity to limit the progress of a longwall.
	Rock burst hazard	The safety of conducting operations.
	Water hazard	Disrupting or preventing the normal course of a longwall. The safety of conducting operations.
Technical factors		
1.	Production capacity	The necessity to limit the progress of a longwall in case of a failure to adjust to the production capabilities of horizontal and vertical transport and of the processing plant.
2.	Longwall length	Technical problems related to the straightness of the longwall face. The safety of conducting operations.
3.	Technical equipment	Too low efficiency – a failure to achieve planned production effects. Too high efficiency – the payment of unnecessary expenses related to the purchase or lease of machines and devices.
Organisational factors		
1.	Efficient working time	Improving the efficiency, augmenting the effects of concentrating production.
2.	Longwall shift system with production	

A similar difficulty is to be expected in the case of seams susceptible to rock bursts. Regardless of other arrangements of active prevention (e.g. the flooding of a seam, stress relaxation drilling, shock blasting), it is often necessary to limit the progress of the longwall face in order to decrease the concentration of stresses in the seam or in the won coal mass. Also, an extraction plan for a seam susceptible to rock bursts should take into account requirements involving long-term prevention, including maintaining the correct sequence of the extraction of seams or their layers, the optimisation of excavation (avoiding leaving pillars and unextracted remains), performing preceding stress relaxation extraction. In many cases this may considerably hinder the production of the planned results of the concentration of extraction.

In seams categorised as the second or third water hazard degree, an analysis involving the amount of water which may flow into a longwall should be conducted already at the extraction planning stage. There are known instances of stopping longwalls into which the

inflow occurred in such amounts that their equipment was virtually sunk. Planning the concentration of operations in such regions is burdened with a high risk of failing to produce the assumed results.

Technical factors

The satisfying results of an analysis of the geological conditions of a seam enable proceeding to the next stage of planning the assumptions for concentrating extraction, which is the determination of technical factors, which most frequently include:

- establishing the production capacity of the designed longwall, combined with the efficiency of the individual production nodes of the mine,
- determining the optimal longwall length,
- determining the technical equipment used in the longwall and in the conveyance of the extracted material.

The production capacity is the extraction rate possible to achieve within an assumed time interval (which

is usually one day), specified in tonnes of extracted coal or commercial coal. When planning a longwall extraction rate, one should take into account not only the amount of extracted material or coal possible to obtain under certain mining and ventilating conditions, but also the possibilities of transporting it in horizontal and vertical excavations, and subsequently subjecting to processing. Therefore, it should be precisely correlated with the extraction rate obtained in other longwalls and the production capabilities of individual production nodes, including primarily horizontal and vertical transport, as well as of the processing plant [Snopkowski, Sukiennik, 2013]. The lack of coordination in that regard may result in a subsequent limitation of the effects of the concentration of extraction.

The extraction rate possible to produce from a longwall increases along with its increasing length. Theoretically, it could amount even up to 400 m, because this number is allowed by safety regulations involving the ventilation of longwall excavations. However, in practice, such lengths are not designed, primarily because of the difficulties in maintaining a straight front of the longwall – such problems occurred even with lengths of about 300 metres. Each mine has separate technical-organisational conditions, which is why a different optimal longwall length will correspond to each. In general, nowadays there are no longwalls longer than 250 m (the average length in Polish mining in the years 2010-2017 amounted to approximately 208 m).

In the case of planning the concentration of production, longwall length should be a compromise choice between aiming for its increase and the possibilities resulting from the safety conditions for the performance of operations (particularly in methane seams and with low-strength roof rocks) and the technical conditions (maintaining a straight-line face, the operational winning speed of the shearer). Designing longer longwalls in an extracted seam or a part thereof shortens the network of heading excavations which are necessary to conduct extraction. This creates conditions for maintaining preparatory operations slightly ahead. The schedule of their excavation should be developed so as to prevent the preparatory operations from delaying the commencement of extraction, but on the other hand, so as not to perform them so far ahead that the completed excavations would undergo deformation, particularly under the conditions of high rock mass pressures.

As already mentioned, in the process of planning the concentration of production, it is extremely crucial to select proper technical equipment installed at the longwall and along routes conveying the extracted material. With a specified length and height of the longwall, the extraction rate will be affected primarily by the progress of its face, depending mainly on the duration of one production cycle – the travel of the winning

machine and the movement of the powered support section. Modern constructions of winning machines enable increasing the rate of progress and winning (for shearers – even above 20 m/min, for planers – above 200 m/min), increasing the range of the winning parts of shearers (even above 1000 mm), pocketless winning. Longwall stoppages caused by malfunctions may be prevented by systems which automatically diagnose overloads and control the basic operating parameters.

The constructional solutions of modern powered support sections should be adjusted to these parameters. Apart from the fact that they will provide the required bearing capacity, they should be provided with actuators enabling a wider range for the movement of sections, adjusted to a wider range of the shearer's parts, tiltable and extendable roof bars being in constant contact with the roof during all operations, and electro-hydraulic control with a system controlling the straightness of the longwall.

The third element of the powered longwall complex should be a scraper conveyor with an increased width of troughs, exceeding even 1000 mm, provided with a lateral outlet, a low over-run drive, a soft start system and chain tightening subsystems.

Longwall complexes should be supplemented with powered support sections of an intersection of the longwall with the bottom gallery, the devices for moving the drives of the longwall conveyor, a bottom scraper conveyor with an increased width of troughs and extracted material conveyors with capacities (belt width, speed) selected so as to avoid impeding the progress rate of the longwall face [Kęsek, 2017].

One should strongly point out another very significant problem in the process of planning the concentration of production. The presented required equipment of a mechanised complex and devices for the conveyance of the extracted material is very expensive. Therefore, its selection should be preceded by a very careful analysis of the above-mentioned geological and mining conditions, intended to determine whether any one of the factors would not limit obtaining the planned production results. Because, in such a case, the installation of a highly efficient expensive equipment would only result in incurring heavy financial losses in this regard.

Organisational factors

The effect of the concentration of production, meaning the extraction rate produced from one longwall, results from the reliability of the used mechanised equipment, its efficiency and operating time. Assuming that:

- the reliability of machines and devices is guaranteed by their modern construction and by being operated by specialised workers,
- at the planning stage, a careful analysis and identification have been performed for all fac-

tors which could affect the efficiency of used machines and devices as declared by producers, one can conclude that the resulting extraction rate will depend on their effective working time, including in particular the winning machine – a shearer or a planer.

In thoroughly mechanised longwall excavations there is a clear merging of the individual operating processes in one work cycle of the winning machine. Therefore, the structure of an operating cycle in a longwall has the nature of a pipeline form of organising the operations. The utilisation of the installed mechanised system is measured by the so-called production pipelining ratio “p” [Turek, 2007]:

$$p = T_e / T_z$$

where: “ T_e ” stands for the working time of a winning machine and “ T_z ” for the working time of a longwall crew during a single shift.

From the dependence it can be seen that with a specified working time of the crew, the production pipelining rate – meaning the efficiency – will become higher with the increasing effective working time of the winning machine. Therefore, the assumptions presented above regarding the proper selection of mechanised equipment are of extreme importance, including, for example:

- fast movement of the powered support section using electrohydraulic steering,
- low overrun drives of the longwall conveyor eliminating the necessity to prepare recesses for sumping the winning parts of the longwall shearer,
- efficiency of devices conveying the extracted material which does not hinder the progress of the winning machine.

Obviously, it is also important for the working time of the longwall crew to be as long as possible. There-

fore, while designing the concentration of extraction, one should consider problems related to shortening the time necessary for the workers to arrive at / leave the longwall, e.g. by using transport devices directly reaching the workplace.

As shown, extraction rate during a production shift is a result of the efficiency of a winning machine and effective working time. When wishing to obtain the best results in terms of the concentration of production, the organisation of work in the mine must be changed so as to aim for an increase in the number of shifts during the day. The shaping of longwall shift work with production in Polish black coal mining in the years 1990-2017 is presented in figure 6.

Since 1990, the shift work of active longwalls has increased by almost 60%. It is also important that one can notice a continuous, systematic increase over the last three years, which evidences the implementation of actions intended to improve the efficiency of mines.

Summary

High concentration of extraction is very significant for lowering its unit cost. However, it cannot be introduced in a mine without considering a number of factors which in a decisive manner determine the results produced in that regard. They include factors related to the specifics of the mining activity and the proper use of machines and devices. Failure to take them into account while planning the level of concentration will always lead to a considerable reduction of the expected results or even to incurring considerable financial losses.

A summary of all factors analysed in the paper along with the determination of their impact on producing the results of concentration is presented in table 1.

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Czynniki determinujące poziom planowanej koncentracji produkcji węgla kamiennego w polskim górnictwie

Procesy restrukturyzacyjne prowadzone od lat w polskim górnictwie węgla kamiennego były wdrażane w oparciu o wiele programów i strategii. Różniły się one między sobą zakresem oraz sposobem ujmowania problemów, lecz wszystkie miały jeden cel – obniżenie kosztów i poprawę efektywności funkcjonowania. Celem artykułu jest przedstawienie wybranych czynników organizacyjnych i technicznych, które determinują planowanie koncentracji produkcji węgla kamiennego w polskim przedsiębiorstwie górnictwym.

Słowa kluczowe: przedsiębiorstwo górnicze, proces restrukturyzacji, efektywność