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Longwall shearers for exploiting thin coal seams as well as thin and highly inclined coal seams

Due to a number of advantages, mechanized longwall systems are applied to exploit seams characterized by a wide range of thicknesses. In the case of thin seams as well as thin and highly inclined ones, there are numerous solutions for longwall shearers that allow for the exploitation of coal seams with a minimum thickness of 0.4 m and a gradient of up to 85°. The article focuses on longwall systems designed for such seam mining. The most important assumptions and advantages of longwall exploitation are presented, and mining machines that are key elements of mechanized longwall systems are discussed. Attention has also been drawn to the various solutions of shearers that are currently used on the domestic market. A wide range of available solutions allowed for distinguishing and presenting ten types of shearers.

Key words: thin seams, inclined seams, mechanized mining, longwall systems, longwall shearers

1. INTRODUCTION

Extracting minerals from deposits starts from the most attractive ones in terms of profitability and technical difficulties. This is particularly important for underground mining. In the case of hard coal occurring in the form of beds, thin and highly inclined seams are very often omitted (as long as their exploitation is not necessary). However, in many countries, an increasing interest in these seams can be observed. This interest results largely from their considerable amounts as well as the necessity to rationally use all available sources of energy. Especially in recent years, more and more attention has been paid to the possibility of the commercially viable exploitation of thin and highly inclined seams. In the case of Poland, thin seams can be considered those that have a minimum thickness of 1.0 m; however, in some countries, seams as thin as 0.4 m are selected (the upper limit is assumed to be 1.6 m). Over 1.6 m, the use of classic shearing (or plowing technology under favorable conditions) does not pose any problems typical of low excavations.

The most important element of a mechanized longwall mining system is the mining machine. The min-

ing machine can be a longwall shearer or a static coal plow. Despite using only two types of machines, the range of available solutions is very wide. An analysis of the solutions currently available around the world (especially in the case of longwall shearers) allows us to conclude that particular types differ considerably from each other.

2. SYSTEMS FOR LOW AND HIGHLY INCLINED LONGWALLS

Irrespective of its thickness, hard coal deposited in the form of a seam determines the manner of its exploitation. The most favorable way of mining a seam that allows for the highly efficient use of the deposit is longwall mining with a mechanized longwall system. This study is focused on presenting various solutions of the longwall shearer, which is the mining machine in the system. Shearers used in Poland as well as those that are not common on our market have been presented. This applies in particular to shearers applied for mining thin seams produced by the Chinese company Beijing HOT Mining Tech Co., Ltd. [1], shearers for seams that are both thin and highly inclined

produced by the Spanish company Mackina-Westfalia, S.A. [2], and shearers produced by Corum Group [3]. All of the available products manufactured by companies whose offers include classic and the most frequently applied longwall shearers as well as static coal plows (including their technical parameters) have been discussed in book [4], whereas information on non-typical solutions applied under specific conditions can be found in articles [5, 6].

Mining with a longwall system involves cutting a coal seam with headings and connecting two headings with a longwall cross-cut having a length of L corresponding to the longwall length and height H – close to the thickness of the seam. The longwall can have a longitudinal slope of α . These excavations form the mine face (Fig. 1). The longwall that has been made available by two headings ensures ventilation, the possibility for efficient transportation, and haulage of the output. Currently, a longwall working is equipped with a shearing or plowing mining system (which, similar to the longwall technology, have been described in literature [7–10]).

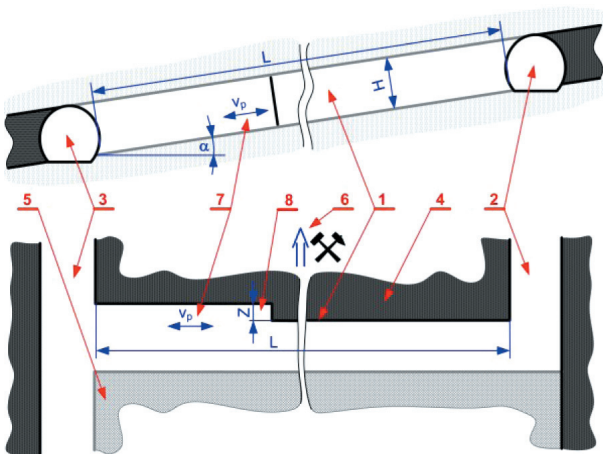


Fig. 1. Diagram of longwall working: 1 – face, 2 – top gate, 3 – bottom gate, 4 – unmined coal; 5 – goafs, 6 – exploitation direction, 7 – direction of machine cutting, 8 – web on solid coal, v_p – shearer’s haulage speed, α – angle of longwall longitudinal inclination, H – longwall’s height, L – longwall’s length, Z – web

Equipped with a cutting machine, longwall conveyor, and powered support, the mechanized longwall mining system enables the process of solid coal cutting and loading as well as mined rock haulage from the longwall. Longwall systems differ depending on the height and length of the longwall, seam slope, and mining-geological conditions. The mining machine moves with a speed of v_p and cuts the solid coal at

a web depth of Z . Cutting can take place in one or two directions. Two-way mining is the most effective, whereas one-way mining is recommended in the case of problems with the cutting or loading of the mined rock.

Mechanized systems applied in highly inclined seams frequently differ from classic longwall shearing systems. It is worth having a closer look at these differences. In practice, these systems as well as the machines are adjusted each time to the local conditions and can differ significantly from one another due to changeable conditions. The system equipment in the case of longwalls with longitudinal inclinations ranging from 30° to 85° consists only of a shearer and powered support, whereas the armored face conveyor is located in the haulage heading below the chutes. A characteristic feature of the shearer applied is the lack of a fitted haulage drive and movement directly on the floor; that is, direct contact of the shearer’s sliding plate with the floor. The shearer is hauled by a two-line winch, with one emergency line. Guiding along the exploited longwall is ensured by the shearer’s slides (which are installed from the side of the goafs) and cooperate with the slide beams (which are connected with the support section feed mechanism). The shearer cuts the longwall when moving towards the top gate. Due to the high slope, the mined rock rolls down by itself towards the haulage heading. When the cutting is finished and the support has been pulled up, the shearer is lowered towards the niche (where the cutting process starts again) [7]. Apart from shearers cutting in highly inclined longwalls, plowing systems can also be applied [3, 4].

3. CUTTING LONGWALL SHEARERS

Irrespective of the thickness of a seam, the most popular longwall shearers are currently classic two-cutting head shearers moving on a conveyor by means of a chainless haulage system. The longwall shearers used in Poland can be divided into three types:

- two-arm, two-head cutting shearers with a chainless haulage system and a frame over the conveyor (Fig. 2a);
- two-arm, two-head cutting shearers with a chainless haulage system with a frame running next to the conveyor (Fig. 2b);
- armless two-head cutting shearer with a chain haulage system (Fig. 2c) [5, 11].

However, when referring to the state-of-the-art of global technology, one should pay attention to the following types of shearers:

- two-arm, two-head cutting shearer with a chain haulage system;
- one-arm, one-head cutting shearer with a chainless haulage system;
- armless one-head cutting shearer (AGH concept) (Fig. 2d);
- armless two-head cutting shearer with vertical axes (Fig. 2c);
- two-arm, two-head cutting shearers with a chain haulage system for direct work on the floor (Fig. 2f);
- one-arm, one-head cutting shearer with a chain haulage system for direct work on the floor (Fig. 2g);
- armless one-head cutting shearer with a chain haulage system for direct work on the floor (Fig. 2h).

Historically, machines with different configurations of heads and drives have been applied in the global and Polish mining industry. In the aspect of thin seams, non-standard solutions intended for special conditions (for example, high inclinations or ultra-thin seams) are not applied in Poland. Apart from the best-known shearers, examples of mining machines offered by the above-mentioned companies (Mackina-Westfalia S.A., Beijing HOT Mining Tech Co., Ltd., and Corum Group) will be quoted as examples of interesting solutions, whereas detailed data as well as the remaining models can be found in the listed literature and in the producers' catalogs.

Established in 1961, Polish company Kopex Machinery S.A. [11] is known for the production of mining machines (longwall shearers in particular). Together with the KOPEX group, Kopex Machinery is currently a subsidiary of FAMUR S.A [12]. The KSW-460NE1 shearer (Fig. 3) is a narrow-arm longwall shearer with an electric haulage drive that moves on a conveyor. It has two arms and two heads. These features are typical of the classic shearers used for medium and thick seams. The Kopex KSW-460NE1 shearer is equipped with a control system with cutting memory that cooperates with the longwall system's superordinate control. It is designed to mine coal in longwalls with heights ranging from 1.35 m to 2.4 m. The output of its cutting heads is 2×200 kW.

Established in 1864, German company Eickhoff Bergbautechnik GmbH [13] is known mainly for the production of longwall shearers. In its offer, Eickhoff has one shearer whose height of cutting partially overlaps the range of the thickness of thin seams.

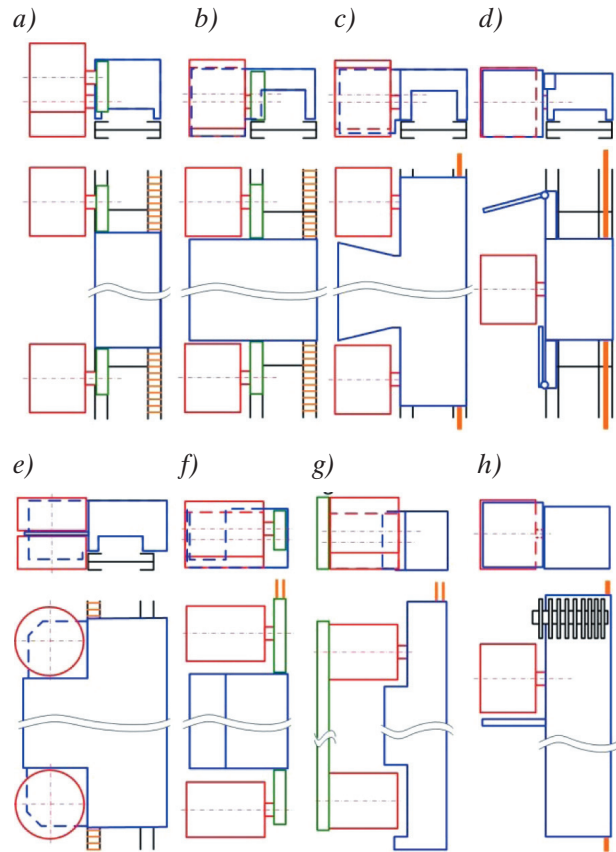


Fig. 2. Diagrams of selected types of longwall shearers for thin and inclined seams (blue – frame; red – cutting head; black – conveyor; green – mobile arm of cutting head; orange – haulage system): a) two-arm, two-head cutting shearer on conveyor; two-head cutting shearer on conveyor; b) two-arm, two-head cutting shearer next to conveyor; c) armless two-head cutting shearer; d) armless one-head cutting shearer designed by AGH; e) armless two-head cutting shearer with vertical axes; f) two-arm, two-head cutting shearer for direct work on floor; g) one-arm, two-head cutting shearer; h) armless one-head cutting shearer with conveyor



Fig. 3. KSW-460NE1 longwall shearer produced by Kopex Machinery

This is the SL 300 L shearer, designed for work on longwalls whose heights range from 1.2 m to 2.0 m (Fig. 4).

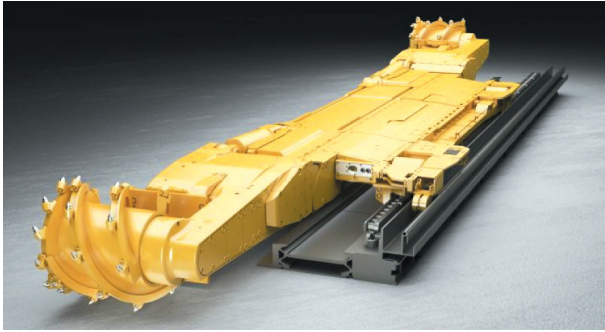


Fig. 4. SL 300 L longwall shearer produced by Eickhoff

The SL 300 L shearer is characterized by a two-arm, two-head construction. It is equipped with a chainless haulage system, and its frame moves along a conveyor. Unlike the competitors' products, the arms lifting the cylinders have been installed over the frame. The shearer is equipped with a 2×300 kW drive of the cutting heads.

A unique solution developed by Kopex is the Mikrus system (Fig. 5) with a cutting-loading head (GUŁ-500) intended for two-way pocket-less cutting and loading of coal in thin seams. The range of the cutting height depends on the diameter of the cutting head applied (reaching 1.1–1.7 m). The GUŁ-500 shearer allows for changing the height of the cutting to a limited extent; the change can be made when the machine is stopped. The cutting-loading head is moved along the sidewall by means of a chain haulage system of the plowing type, which is driven by electric motors supplied from frequency converters placed in the headings. The shearer is characterized by two-head armless construction. Both heads are mechanically coupled and driven by one motor (with an output of 500 kW).

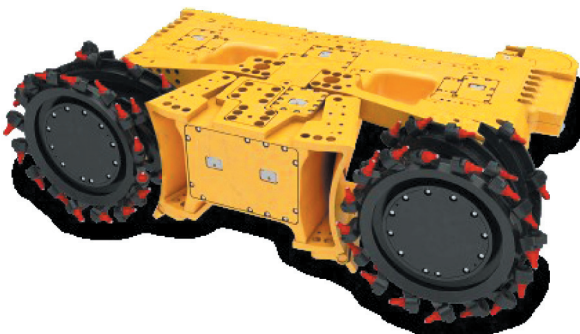


Fig. 5. Mikrus shearer GUŁ-500 produced by Kopex Machinery

Established in 1889, Ukrainian company Corum Group produces underground mining machines. Corum offers a unique longwall shearer solution – the KBT200 (Fig. 6). The shearer is moved on a conveyor by means of a chainless haulage system. The characteristic feature is its armless construction and its cutting head axles that can turn 90° . Vertical axles enable the easier cutting and loading of the mined rock onto the conveyor. The KBT200 shearer is designed for mining coal from seams with thicknesses within a range of 0.8 m to 1.25 m.

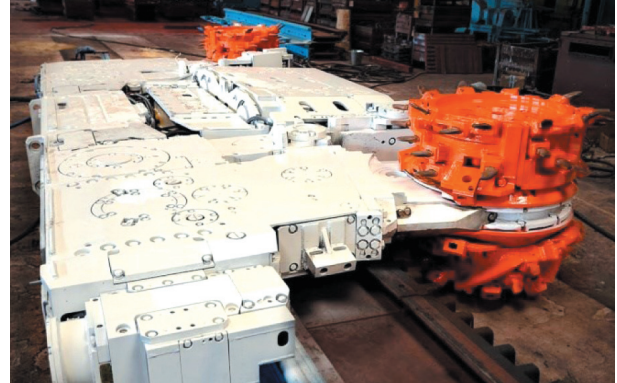


Fig. 6. KBT200 longwall shearer produced by Corum

Mackina-Westfalia S.A. started operating in 1955. It designs and produces mining machines among other things. In 1994, Mackina became independent from the German company Westfalia Lünen while maintaining the profile of its activity.

The two-arm, two-head cutting shearer with a PMAP Mackina chainless haulage system is characterized by classic construction and moves along a conveyor, but it will be presented in more detail due to its constructional features and solutions (which are no longer applied in modern shearers). Motors driving the cutting heads are located in the frame, which requires the use of a so-called wet joint for transmitting the torque by the arm axis of rotation. Additionally, the motor axis is perpendicular to the axis of the cutting head, which requires the application of an intersecting axis gear. Moreover, the PMAP shearer can also be installed in a version with one cutting head. The PMAP shearer is designed for work in walls with thicknesses ranging from 1.25 m to 2.50 m. The output of the cutting head drive is 2×120 kW.

The Mackina RPB60 and PMA80 models are two-head and two-arm shearers with a chain haulage system that are intended for direct work on floors in walls characterized by high longitudinal slopes within a range of 35° to 85° . In both shearers, the

same arrangement of the frame, arms with cutting heads, haulage arm, and winch has been applied. The RPB60 shearer (Fig. 7) cuts ultra-thin seams with thicknesses ranging from 0.38 m to 0.85 m, with the output of the cutting head motors of 2×30 kW. On the other hand, the PMA80 cuts thin and medium seams with thicknesses within a range of 1.10 m to 2.5 m and with a cutting head output of 2×120 kW. In both shearers, the motors driving the cutting heads are mounted in the frame, but their axles are parallel; this simplifies the transmission of torque.

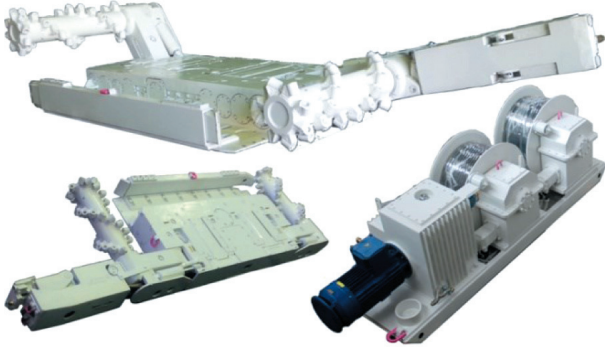


Fig. 7. RPB60 two-head cutting shearer produced by Mackina for thin seams, and winch

An example of unique construction is the Mackina TEMP-H shearer (Fig. 8), which has two cutting heads but only one arm as well as a chain haulage system. It is designed to work directly on a floor in thin seams with high longitudinal slopes within a range of 30° to 85° . Its uniqueness is visible in the solutions applied, which are different than those found in the remaining shearers for inclined seams. This shearer is equipped with one electric motor with an output of 80 kW, which drives the lower cutting head (first) by a hydrostatic torque converter (pump-motor), whereas the upper head (second) is driven from the lower cutting head by means of a chain begirding the arm. The chain has both driving and cutting functions, so it is equipped with picks. Application of conical picks on the cutting heads while the chain has been equipped with radial tools is also atypical.

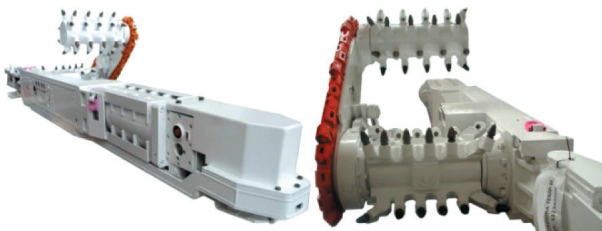


Fig. 8. TEMP-H two-head shearer for thin seams produced by Mackina

Beijing HOT Mining Tech Co., Ltd. (hereinafter referred to as HOT) is a supplier of products and services for mining and mineral processing. It offers machines produced by four external companies belonging to the group of Original Equipment Manufacturers (so-called OEM), which means that only HOT puts its name on these products. It does not change the fact that longwall shearers offered by HOT are worth quoting.

The HMG100/250-PBD HOT two-arm, two-head shearer is also characterized by classic construction and moves along a conveyor, but it is not equipped with tractors. The drives of its chain haulage system are located in the headings.

Another solution offered by HOT is a one-arm, one-head cutting shearer with a chainless haulage system, the three models of which form the HMG series. These shearers move in a traditional way along a conveyor using one tractor and double frame saw wheels in a popular system called Eicotrack (Fig. 9). The HMG shearers are equipped with cutting head motors with outputs of 100 kW, 100 kW, and 120 kW, respectively, and are designed to cut walls with heights ranging from 0.75 to 1.2 m.



Fig. 9. HMG100/111-TWD one-head cutting shearer for thin seams produced by HOT

The last discussed solution is the HMG100-TP shearer offered by HOT, which has a one-head armless construction with a chain haulage system for direct work on a floor; it is intended for highly inclined seams (Fig. 10). Unlike the remaining shearers of this type, this shearer loads coal onto the face conveyor by means of a short chain conveyor, which transports the mined rock directly from the cutting head area. The shearer does not have a haulage drive installed in the frame and requires the use of a winch. Depending on the diameter of the cutting head driven by a motor with an output of 100 kW, the shearer is designed for work in longwalls with thicknesses ranging from 0.44 to 0.9 m.

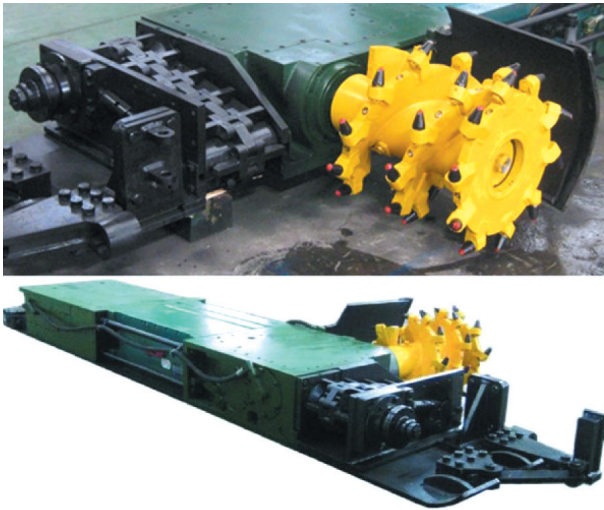


Fig. 10. HMG100-TP one-head cutting shearer for ultra-thin seams offered by HOT

4. ONE-HEAD SHEARER FOR CUTTING ULTRA-THIN SEAMS

Despite the considerable differences in the construction of longwall cutting shearers and static coal plows, the key problems related to the increasing of daily output still remain unsolved [14]. The solution that allows for achieving a satisfactory daily output in longwalls with heights ranging from 1.0 to 1.6 m (which is economically justified under Polish conditions) is a longwall system equipped with a one-head shearer. The one-head cutting shearer combines the advantages of plowing and cutting-loading technology while eliminating their basic drawbacks. The said solution has been developed at AGH and offers a promising alternative to the currently used longwall systems.

Figure 11 presents one-head cutting shearer (I) mounted on face conveyor (II). According to the assumptions, the shearer consists of frame (1), whose main assembly is the driving unit (2) with a milling spatial head mounted on the shaft end (3).

Loaders are fixed to the frame by means of the arms (4) and cylinders (5). The first loader (6) is in the active position, whereas the second (7) is in the passive one. The frame has two caving skids (8) and two sidewall skids (9). The caving skids (8) are connected with the drive chain (13). The frame from the caving side has a cable handler grip (11) with cables. Each loader is equipped with rolls (10) that prevent it from getting blocked on rough surfaces. The cables are placed in the cable handler (11) and

are guided in the gate (12). Shearer I is drawn by means of the chain (13). The sidewall skid of the shearer (9) moves along the conveyor's sidewall guide (15), whereas the caving skid (8) moves along the conveyor's caving guide (14). The system has been equipped with a hydraulic cylinder for vertical horizon control (16).

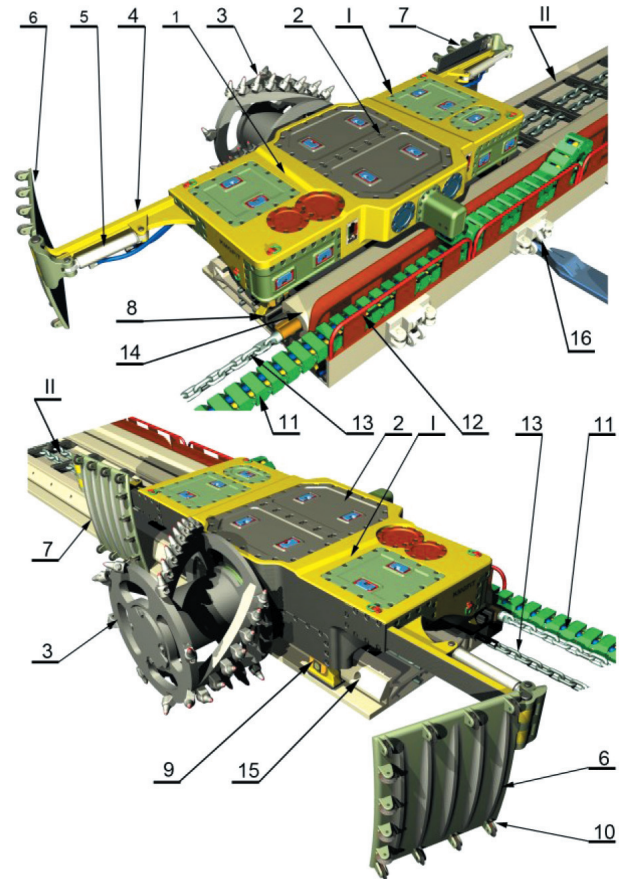


Fig. 11. Solution of one-head cutting shearer on face conveyor developed by AGH

Such a solution enables the effective exploitation of seams owing to work in a two-way mining longwall system as well as the application of cutting, separating the cutting process from the loading process, using full work automation, implementing a chain haulage system, and creating possibilities to start a new sequence of cutting without sumping [14, 15].

5. SUMMARY

Producers of mining machines in Poland and abroad offer many types of cutting shearers and coal plows designed to work in mechanized longwall systems. The solutions available in various countries (especially in the case of shearers) differ from classic

construction; this is caused by the local natural and economic conditions. The review and division of longwall shearers presented in this article draws attention to the multitude of solutions. The reason for such a situation is the constant search for machines dedicated to particular specific conditions as well as ever-growing technical possibilities, especially the development of automation (which allows for eliminating man from particularly dangerous areas).

The presented currently applied longwall shearers frequently enable only several hundred tons of daily output to be obtained from a face, which is not acceptable under Polish conditions.

In global solutions, apart from machines included in longwall shearer systems, also mining machines designed for other methods and systems of exploitation are applied [4, 5].

The conceptual and prospective solution proposed by AGH (a system for thin-seam exploitation) is equipped with a one-head cutting shearer designed to work in two-way mining technology. A characteristic feature of this technology is, in this case, the lack of the sumping phase and full web work over the whole length of the face. Application of a cutting head allows for a positive evaluation of the possibility to implement such a shearer for work in seams with disturbances and coals characterized by the highest machinability index. Resignation from loading by means of machine cutting heads and withdrawing the staff from the face eliminates the major limitations of classic shearing technology.

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