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Application of gearboxes in mining machines/equipment

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Abstract:

The mining industry has a high demand for mining support equipment. The growing demand for raw materials results in an increased supply of equipment that streamlines the achievement of intended goals. This article presents the basic gearboxes used in the mining machinery and equipment. It describes the basic classification of gear transmissions and presents the basic technical parameters of gear transmissions used in hard coal mines. Machines used in hard coal mining are particularly susceptible to failure, which negatively impacts the efficiency of mining plants. The stringent requirements for failure-free operation have forced manufacturers to ensure the longest possible operating time of their machines. Conclusions drawn from observing the operation of the currently used machines have allowed manufacturers of gear transmissions/reducers to determine actions aimed primarily at extending the operating life of drive units for raw material extraction.

Keywords: gear transmission, mining industry, manufacture, workforce

1. Introduction

Machinery and equipment manufacturers supplying their products to mining plants often struggle with maintaining a consistent product range. A sudden increase in orders leads to increased production costs [1, 2]. Timely completion of specific tasks requires increased staffing in specific positions or overtime work, which significantly increases manufacture costs. However, considering the rapid decline in orders, it is clear that maintaining the necessary workforce, which is essential for maintaining production continuity, even with a significant reduction in sales volume, generates additional costs [3]. Examples of additional production costs associated with a decline in orders include the costs of downtime for key machine tools, despite their full operational capacity, and the maintenance of machine tool operators despite the often-high costs of employee salaries [4, 5, 6]. Plants producing machinery and equipment for the mining industry are forced to seek new markets for their products or begin production of entirely new products for the sectors other than mining industry, given the downturn in the mining industry. Very often, barriers to entry into a new production segment are very difficult to overcome. Even when a plant possesses a high level of technology and a highly qualified workforce, it is difficult to overcome the economic barrier (low product prices) [7]. An example is the agricultural machinery industry, which is characterized by low product manufacturing costs and intense competition in the supplier market. Research and development at plants is largely focused on current production needs. New machines that allow for increased production are highly desirable in the mining sector. Research and Development Centers place particular emphasis not only on equipment for mining minerals but also on their transport to the surface.

2. Types of gear transmission and their characteristics

Cylindrical gears

A cylindrical gear is the simplest gear reducer, both in design and manufacture. Design assumptions are usually limited to strength calculations of the gears and bearings to ensure failure-free operation under operating conditions [8]. Helical gears can be designed in two variants:

- spur gears,
- cylindrical gears with helical teeth.

The accuracy classes of the gears depend on the peripheral speed of the gears; the higher the speed, the higher the accuracy class. Accuracy classes 5 to 7 are typically used. This significantly affects the gear noise during operation and the strength parameters of the gears. Cylindrical gears are most often used in belt conveyor drives.

Bevel Gears

Bevel gears are widely used in the mining industry due to the small work surface required to install the drive motor, which is mounted perpendicular to the gear output shaft. A bevel gear has a bevel pinion and a bevel gear that transmit torque with crossed axes, operating at a 90° angle. Bevel gears are most commonly used in belt conveyor drives, scraper conveyors, and mine locomotive drive wheels.

Worm Gears

Worm gears are less widely used in the mining industry compared to the aforementioned types of gear units. A worm gear is designed to transmit rotary motion with crossed axes at a 90° angle. Thanks to the ability to use large gear ratios in a single stage, the gear unit has a compact design, significantly improving its suitability for use in difficult-to-install locations. A worm gear consists of a worm and a worm wheel. In the mining industry, worm gears are most often used in belt tensioning mechanisms installed in belt conveyors.

Planetary Gears

A planetary gear differs significantly from the reducers described above. Its design is characterized by the positioning of the input shaft (sun shaft) on a single axis and the output shaft in the form of a planetary connector (yoke) and a gear ring with internal teeth. Torque from the high-speed shaft is transmitted through gears (sun wheels), the number of which, depending on the gear design, ranges from 2 to 5. Planetary gears are used in scraper conveyors, less frequently in belt conveyors, and increasingly in the drives of suspended monorails used in mine transport.

3. Gears in mining machines/equipment

The most commonly used gears in the mining industry are:

- cylindrical gears,
- bevel gears,
- planetary gears.

These gears are combined as angular-cylindrical, angular-planetary, or angular-cylindrical-planetary assemblies [9, 10, 11].

Gears operating in hard coal mines are widely used in almost all equipment used for extracting the run-of-mine [1].

Hard coal mining is extremely labor-intensive – this is due to the difficult mining conditions, primarily the difficulties associated with the extraction of solid coal and the transport of run-of-mine. Process of mining the hard coal seams generally consists in three stages.

Work related to opening the coal bed, consisting in development of roadways for opening the mining faces where the main extraction of coal takes place. The machines used to develop such roadways are called roadheaders. An example of an AM-50 roadheader and a section of a roadway is shown in Figure 1.

Fig. 1. AM-50 Roadheader [12, 13]

Mining operations involving the extraction of minerals from exploitation walls are performed using longwall shearers and coal plows. An example of mining the solid coal using a longwall shearer is shown in Figure 2.

Fig. 2. Longwall shearer [12, 13]

Another type of the machine for mining the solid coal – a coal plow, is shown in Fig. 3. Coal plows are not as popular in Polish hard coal mines as longwall shearers, but recently there has been an increase in interest in this type of machines used for mining solid coal from mining walls.

Fig. 3. Coal plow [12, 13]

Transportation is a very important element that has a huge impact on the production volume [11]. This is realized by scraper conveyors, and then belt conveyors. A fragment of the scraper conveyor is shown in Figure 4.

Fig. 4. Scraper conveyor [12, 13]

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4. Application of different types of gears in the mining industry

The mining industry is characterized by a very high demand for mining equipment. The growing demand for raw materials is resulting in an increased supply of equipment that improves the achievement of intended goals.

Machinery used in hard coal mining is particularly susceptible to breakdowns, which negatively impacts mine efficiency. The stringent requirements for trouble-free operation have forced manufacturers to ensure the longest possible operating time for their machines.

Conclusions drawn from observing the operation of currently used machines have allowed us to define directions of work aimed primarily at extending operating life and minimizing breakdowns. These actions will translate into reduced downtime while simultaneously increasing the efficiency of raw material extraction.

Conveyors are the most important means of transport during the mineral extraction process. There are two main types of conveyors that enable the transport of ore from the extraction point to the storage site: scraper conveyors and belt conveyors.

Scraper Conveyors

Scraper conveyors (Fig. 5) are most commonly used in hard coal mines. A sketch of a heavy-duty scraper conveyor is used in longwall systems.

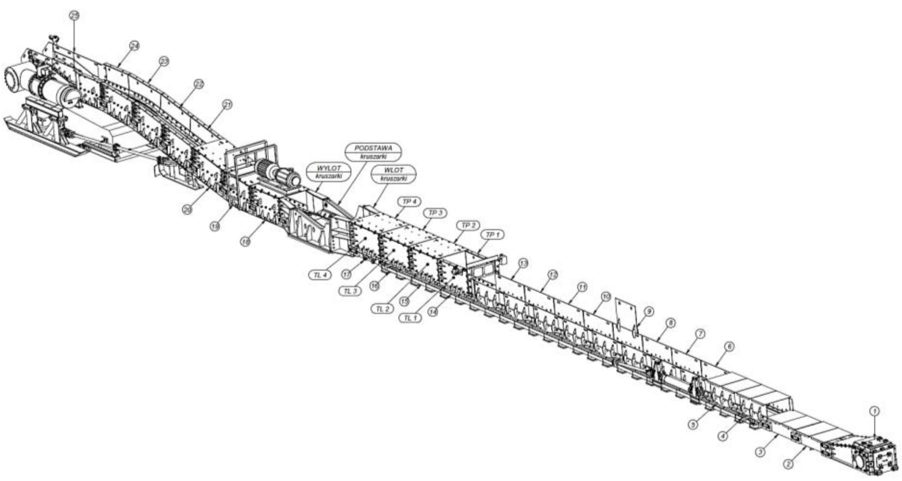

Fig. 5. A sketch of a heavy-duty scraper conveyor [12, 13]

These devices are designed to transport mined material directly from the coal face, working in conjunction with a mining machine: a longwall shearer or a coal plow. Another application for heavy-duty conveyors is as beam stage loaders, which transport mined material from the Armoured face conveyor (AFC) to a belt conveyor.

The gears most commonly used in heavy-duty scraper conveyors are:

- bevel-helical-planetary gears with a power of 160-650 [kW],
- bevel-planetary gears with a power of 160-650 [kW],
- planetary gears with a power of 160-650 [kW].

A sketch of light-duty scraper conveyor (Fig. 6) is primarily used for preparatory work during roadway development.

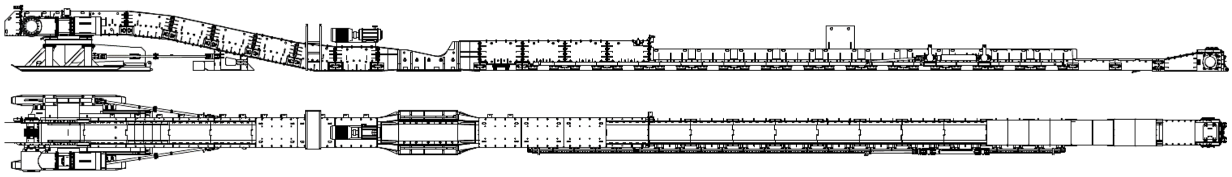

Fig. 6. A sketch of light-duty scraper conveyor [12, 13]

The most well-known device employing a light-duty scraper conveyor is the shearer loader used for development of roadways. The scraper conveyor in this device transports the mined material from the shearer's loading table out of the mining zone. Lightweight conveyors are also used in haul roads where steep slopes prevent the use of a belt conveyor.

There are the following most common gears used in lightweight scraper conveyors:

- angular helical gears with a power of 11-55 [kW],

- angular planetary gears with a power of 15-55 [kW].

Belt Conveyors

A sketch of a belt conveyor (Fig. 7) are mechanical means of transport characterized by a simple design, reliable operation, and high operator safety [11].

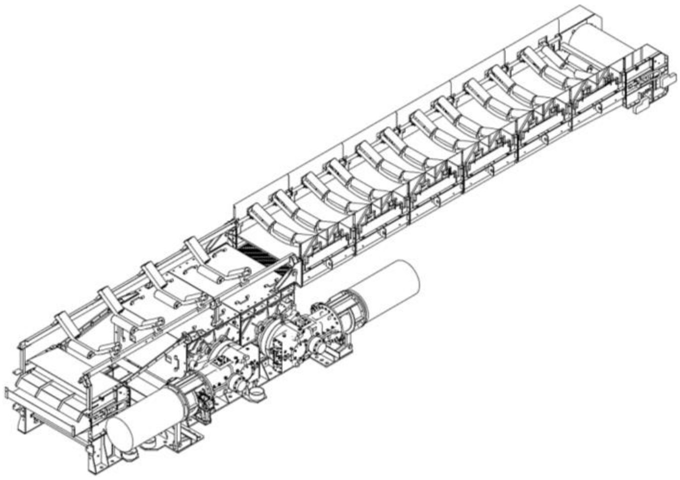

Fig. 7. A sketch of a belt conveyor [12, 13]

These devices are characterized by high efficiency over very long distances (compared to scraper conveyors). Thanks to their low investment and operating costs and advantages (conveyor length, efficiency), they are the main transport devices in underground, open-pit, and rock mining, etc. [11].

The most commonly used gears in belt conveyors are as follows:

- right-angle helical planetary gears with a power of 160-650 [kW],
- right-angle helical gears with a power of 15-1000 [kW],
- right-angle planetary gears with a power of 55-450 [kW],
- helical gears with a power of 30-250 [kW].

Mining machines

Mining the solid coal in hard coal mines is primarily performed using a longwall system, which extracts the vast majority of coal. Longwall shearers (Fig. 2) or coal plows (Fig. 3) are the mining machines mainly used in longwall systems, which provide high mining efficiency. Longwall shearers use cylindrical gears located in the main body and cylindrical-planetary gears that drive the cutting drums [8, 12]. Significantly less mined material is extracted during access work (drilling roadways), which are designed to open the coal seam (coal face) for mining. Currently, roadways are developed using the following two methods:

- the traditional (conventional) system,
- the shearer system.

In the traditional system, mining is performed by drilling blast holes in the coal bed and blasting the face with explosives. To mechanize these operations, rotary and impact drills, as well as various types of loaders, are used. Mined material is transported using conveyors.

In the roadheader system, the basic machine is a roadheader. Roadheaders perform three simultaneous operations: mining, loading, and transporting the mined material away from the roadheader for further transport. Roof supporting is a separate operation, performed when the roadheader is stopped.

The most common roadheader used in hard coal mines is the AM-50 roadheader (Fig. 1). This roadheader achieves very good results, is small in size, and has a compact and robust design. Polish mining machinery industry began producing the AM-50 roadheader in 1977-78 in cooperation with Voest Alpine.

5. Gears installed in equipment used in the mining industry [13]

Gears installed in scraper conveyor drives

The 31.13 bevel-helical gear unit. This is a three-stage gear reducer, the first stage being a bevel gear, and the next two being helical gears. This type of gear is primarily used in light scraper conveyor drives. The gearbox has been in manufacture since the early 1980s.

Technical data for the 31.13 gearbox:

Power - 22 [kW]

Input speed - 1500 [rpm]

Gear ratio - 28.

The 31.05 bevel-helical planetary gearbox is shown in Figure 8. It is a two-stage gear reducer, with a pair of bevel gears in the first gear stage, and a planetary gear in the second gear stage. The gear is used in light scraper conveyor drives [11]. Manufacture began in the mid-1980s.

Technical data for the 31.05 gearbox.

Power - 30 [kW]

Input speed - 1500 [rpm]

Gear ratio - 31.5.

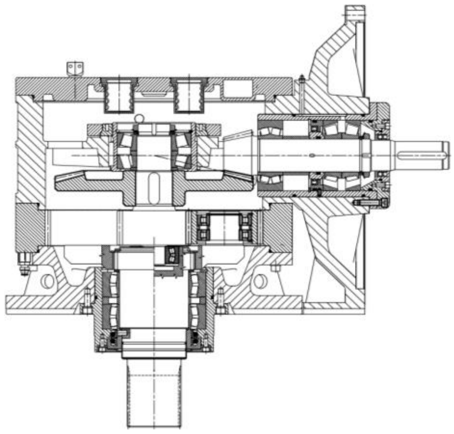

Fig. 8. Diagram of an angular planetary gear-31.05

Gears installed in belt conveyor drives

The 31.20 angular helical gear is a two-stage gear reducer with a pair of bevel gears in the first stage and a pair of cylindrical gears in the second stage. The gear is used in medium-capacity belt conveyors. Manufacture began in 1999.

Gearbox technical data:

Power - 55/75 [kW]

Input speed - 1500 [rpm]

Reduction ratio - 12, 14, 18, 22.

The 31.25 spur gear is shown in Figure 9. It is a three-stage helical gear reducer (all gear stages have spur gears). The gear is used in high-capacity belt conveyor drives. Manufacture began in 2009.

Gearbox technical data:

Power - 132 [kW]

Input speed - 1500 [rpm]

Gear ratio - 16, 19, 21, 25.

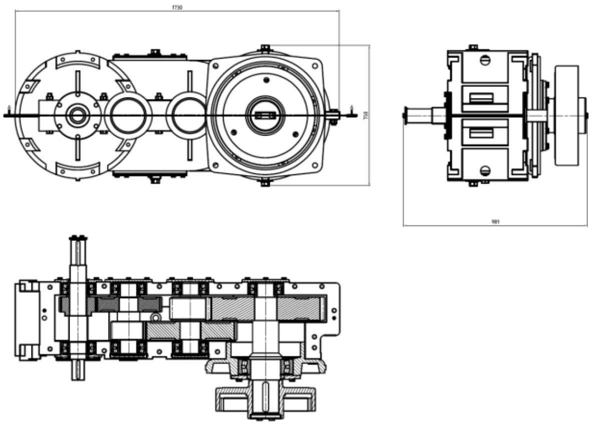

Fig. 9. Spur gear transmission diagram 31.25 [12, 13]

Gears operating in the AM-50 roadheader's component drives

The 21.11 cutting head drive gearbox is a three-stage reduction gear. The first stage consists of a pair of bevel gears, the second stage consists of helical gears, and the third stage, transmitting torque to the reducer output shaft, on which the cutting heads are mounted, consists of spur gears. To provide adequate space for the cutting heads, the third stage has an intermediate gear. Manufacture began in the early 1980s.

Gear technical data.

Power - 100 [kW]

Input speed - 1500 [rpm]

Gear ratio - 20.

The 21.60 cutting head drive gearbox is shown in Figure 10. This is a gear with three gear ratios. The first stage is a pair of bevel gears, the second stage consists of helical gears, and the third stage, transmitting torque to the output shafts of the gear, on which the cutting heads are mounted, has spur gears. To provide adequate space for the heads, the third stage has an intermediate gear. The gearbox has a possibility to install cutting heads with a sectoral spraying system. Manufacture began in 2013.

Technical data:

Power - 132 [kW]

Input speed - 1500 [rpm]

Gear ratio - 16.58.

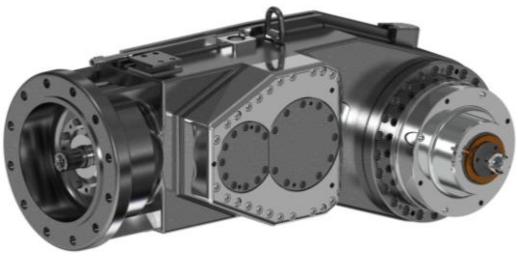

Fig. 10. AM-50 cutting drum gear [12, 13]

The AM-50 roadheader conveyor feeder drive is powered by two helical-angle gears. The 21.42/43 conveyor drive reducer is a two-stage gear unit, the first stage being helical gears, and the second stage being bevel gears. Manufacture of these gears began in the early 1980s.

Technical specifications of the 21.42/43 gear unit:

Power - 11 [kW]

Input speed - 1500 [rpm]

Ratio - 13.

The 21.38/39 loader flippers drive gearboxes are designed to transfer torque from the return shaft of the flight-bar conveyor to the flippers used to load the mined material onto the flight-bar conveyor. The flippers drive gearbox has one gear stage, a pair of bevel gears. Manufacture of these gearboxes began in 2003. Technical data of the 21.38/39 gearbox.

Power - 11 [kW]

Input speed - 115 [rpm]

Gear ratio - 3.2.

Caterpillar chassis drive gearbox 21.59. This reducer consists of a three-stage cylindrical gear and a planetary gear, which transmits torque directly to the caterpillar chassis drive sprocket. Manufacture of the gear began in the early 1990s.

Technical data of the 21.59 gearbox.

Power - 15 [kW]

Input speed - 1500 [rpm]

Gear ratio - 251.

Gear drives used in the equipment supporting the mining operations (rail and suspended transport as well as mining winches). The 33.10 wheelset, shown in Figure 11, drives the rail locomotive shown in Figure 8. The basis for the 33.10 wheelset design is a two-stage reduction gear with bevel gears in the first gear stage and cylindrical gears in the second gear stage. The output shaft of the gearbox also serves as the axle of the wheelset, on which the wheel studs and their rims are mounted. Manufacture of the gearbox began in 2010.

Technical specifications of the 33.10 wheelset gear:

Power - 45 [kW]

Input speed - 1000 [rpm]

Gear ratio - 22.

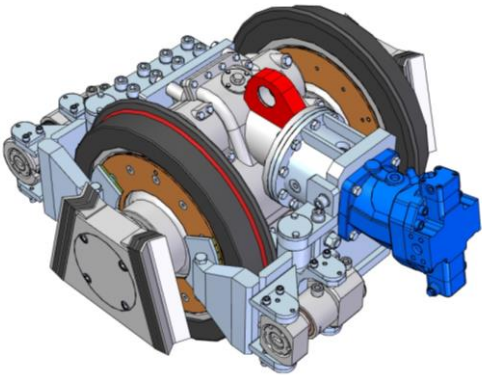

Fig. 11. Rail locomotive wheelset [12, 13]

The 31.29/31 worm-planetary gear unit operating in the mine winch drive shown in Figure 8. This gear unit has a worm gear in the first stage, while the second stage is a planetary gear. Manufacture began in 2006.

Technical parameters of the 31.29/31 gear unit:

Power - 15 [kW]

Input speed - 1500 [rpm]

Gear ratio - 251.

The 33.39/40 worm-planetary gear unit for the suspended monorail drive is shown in Figure 12. It is a two-stage planetary gear unit. This design was custom-made for a company manufacturing the suspended monorails. The need for vertical operation required using the double planetary gear unit. Manufacture began in 2014.

Power - 11 [kW]

Input speed - 1000 [rpm]

Gear ratio - 18.

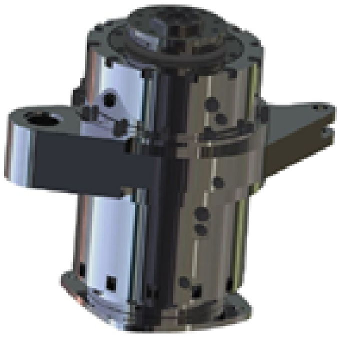

Fig. 12. Planetary gear [12, 13]

6. Implementation of new types of reductors

Analysis of the failure rate of the gearboxes in the drive systems of the AM-50 roadheader, based on completed repairs and service work, allowed us to develop an expert opinion on the operation and failure rate of the gear unit installed on the scraper conveyor of the AM-50 roadheader. The analyzed gearbox is a helical-angle reducer. The first stage consists of a pair of helical gears, while the second stage consists of bevel-arc gears. The bevel-arc gear (passive) is insatlled directly on the gearbox output shaft, which causes its destruction if operated incorrectly. The far-reaching conclusions allowed us to develop assumptions for the preliminary design of a new gearbox. The decision was made to change the gearbox design to a bevel-planetary one. The change in the kinematic system will increase the gearbox failure-free operation time to 3 years (the previous gearbox operated without failure for a maximum of 1.5 years). The new reducer has the same function as its predecessor: transferring torque from the motor to the drive shaft of the scraper conveyor of the AM-50 roadheader. The gear power increased from 11 to 15 kW, while maintaining the same gear ratio. Consequently, the torque on the output shaft was increased, which, given the same conveyor load, will significantly extend the gear service life. During the designing process, significant emphasis was put on the use of high-strength materials and reduced machining costs, using mostly semi-finished products in the form of alloy steel castings. This approach significantly reduced manufacture costs. Cost-saving measures during the designing phase and increased durability of each component allowed the creation of a product that:

- has increased reliability compared to the product it replaces,
- the slight price increase is offset by the extended warranty period of up to 24 months,
- features a universal configuration (right-left reversible gear) where the gear it replaces had to be manufactured in a right-hand and left-hand configuration, which automatically reduces the need for backup gears, reducing the mining plant's inventory costs.

When considering new concepts for gear reducers for the mining industry, the focus was also on gear reducers installed in belt conveyor drives. The decision was made to begin the project of a gear reducer that would be installed in a belt conveyor drive. Market analysis among belt conveyor manufacturers and direct users clearly defined the design assumptions for the new gear.

Technical parameters of the 2RKW-450N 32.40.00.000 angular helical gear (Fig. 13).

- Power: 250 [kW],
- Mounting using a sleeve and clamping ring,
- Reversible system (can be installed on both sides of the conveyor),
- Water cooling of the high-speed shaft system.

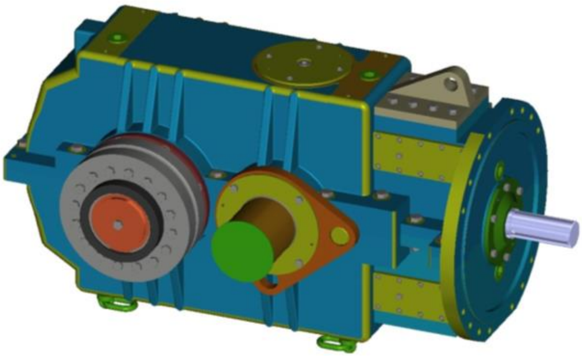

Fig. 13. 2RKW-450N gearbox [12, 13]

The last gear, which was implemented in 2018, is the reducer driving the suspended railway driving mechanism (Fig. 14).

Fig. 14. Angular planetary gear of the suspended monorail drive [12, 13, 14]

Design of this gear was developed at the request of a manufacturer of suspended mine railways. The gear design is adapted to only one suspended railway design.

The 33.60.00.000 gear unit is a planetary angular reducer with a power output of 18.5 kW and the ability to operate the high-speed shaft vertically.

7. Conclusion

The basis for the further development of Zakłady Mechaniczne is the expansion of the gear production process with new design solutions. Current development and research work at the gear manufacturing plants is largely focused on current production needs. New machines enabling increased production are highly sought after in the mining sector. The Research and Development Centers place particular emphasis not only on equipment for mining minerals but also on their transport to the surface.

An equally important aspect of the company operations is its qualified staff, employed at every stage of the organization. Efforts should be made to improve employee qualifications, particularly to supplement positions strategic for the company.

The gear manufacturing process is stable thanks to the implementation of new solutions. Manufacture of gears is being replaced by new design solutions that ensure sales continuity. For

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example, the gradual phasing out of wheel set production for track locomotives has been gradually replaced by manufacturing the gears for suspended monorails operating underground in mines.

However, investments in new infrastructure, machinery, and technology are essential, as their absence significantly limits the company manufacture capabilities. Modernizing the machinery will significantly increase the efficiency of the manufacturing process and the quality of manufactured products.

If gears manufacture declines, the scope of gear repair services should be expanded to the customers outside the mining industry.

References

[1] Biały W.: Górnictwo węgla kamiennego: wybrane problemy funkcjonowania. Wydawnictwo Pracownia Komputerowa Jacka Skalmierskiego 2011.

[2] Biały W., Midor K.: Innowacyjność, Jakość, Zarządzanie. Systemy Wspomagania w Inżynierii Produkcji. Wydawnictwo P.A. NOVA, Gliwice 2013.

[3] Biały W., Zasadzień M.: Wspomaganie Zarządzania Systemami Produkcyjnymi. Systemy Wspomagania w Inżynierii Produkcji: Wydawnictwo P.A. NOVA, Gliwice 2013.

[4] Brzeziński M.: Organizacja produkcji w przedsiębiorstwie. Wydawnictwo Delfin 2013.

[5] Krawiec F.: Zasadnicza zmiana droga do sukcesu przedsiębiorstwa XXI wieku. Difin Warszawa 2007.

[6] Szatkowski K. Przygotowanie produkcji. Wydawnictwo Naukowe PWN, Warszawa 2008

[7] Czader W., Drewniak J., Pieczora E.: Komputerowo wspomagane projektowanie bezpiecznych napędów mechanicznych stosowanych również w górnictwie. IX Międzynarodowa Konferencja Naukowo-Techniczna KOMTECH 2008. Nowoczesne, niezawodne i bezpieczne systemy mechanizacyjne dla górnictwa; CMG KOMAG; Szczyrk 17-19 listopad 2008.

[8] PN-79/M-88522.01, Przekładnie zębate-walcowe. Dokładność wykonania. Nazwy, określenia i wartości odchyłek.

[9] Ochęduszko K.: Koła zębate – konstrukcja. Wydawnictwa Naukowo-Techniczne, Warszawa 1974.

[10] Ochęduszko K.: Koła zębate – wykonanie i montaż. Wydawnictwa Naukowo-Techniczne, Warszawa 1971.

[11] Antoniak J.: Przenośniki taśmowe w górnictwie podziemnym i odkrywkowym. Wydawnictwo Politechniki Śląskiej Gliwice 2006.

[12] Biały W., Wilkowski G.: Przekładnie zębate stosowane w maszynach/urządzeniach górniczych. Systemy Wspomagania w Inżynierii Produkcji. Volume 8 Issue 1 pp. 376-391 [2019]

[13] Biały W., Wilkowski G.: Analiza procesu produkcji/sprzedaży przekładni zębatych, stosowanych w napędach maszyn/urządzeń górniczych. Studium przypadku. Systemy Wspomagania w Inżynierii Produkcji. Volume 8 Issue 2 pp. 56-69 2019

[14] Zakłady Mechaniczne: Dokumentacja Techniczno-Ruchowa reduktorów. 2019 Volume 8 Issue 2, Multidyscyplinarne Aspekty Inżynierii Produkcji

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