

RAJMUND HORST  
JAN ZDZIEBKO

## Mechanization and automation in the production processes of Polska Grupa Górnicza S.A.

*In Polska Grupa Górnicza S.A., actions are still being taken to mechanize and automate work, striving to increase production efficiency and reduce the physical burden on miners. Mechanization of works covers further areas which enable the process of automation of underground mining processes. The article presents the leading solutions in the field of mechanization and automation in mine transport, the mechanization of sharing and auxiliary works, and the remote control of belt conveyors and main switchboards.*

*The article also contains a description of the work carried out which support automation processes: activities in the standardization of the equipment of longwall systems, pressure monitoring of powered supports, wireless communication, electronic identification of production assets, and the visualization of the operating parameters of machines and devices.*

Key words: *hard coal production, mining machines, mechanization, automation*

### 1. INTRODUCTION

Due to the increasing challenges faced by economic entities in the hard coal mining industry, technical support is required to achieve such solutions that guarantee the achievement of the assumed technical and economic indicators by the user. The optimization of production costs is one of the key tasks faced by managing and supervising hard coal mine operations. The constant search for the best solution to achieve the set goal requires the management of each level to use effective methods and means of operation. Mechanization, automation, and computerization of the production process ensure the effective implementation of activities that will enable the planned organizational and economic effects to be achieved at the mining operation stage [1]. The control and monitoring systems, adapted and learned, are increasingly widely used in industrial practice. The techniques of the Internet of Things (IoT) and

direct communication machine to machine (M2M) increasingly affect the structure and functionality of control systems used, shaping the idea of Industry 4.0. IoT-compatible control systems use intelligent communication networks, often with a high degree of complexity, connecting individual components, modules, actuators and sensors [2].

Polska Grupa Górnicza S.A. operates in increasingly difficult mining and geological conditions which require the use of new technical solutions to ensure the safety of employees while increasing the efficiency of the coal mining process.

Observing the modern industry, one can see yet another factor determining the orientation of enterprises to increase the degree of automation and mechanization, namely the growing personnel costs of employees. This encourages the effective use of their working time by relieving the workload in hazardous, monotonous and repetitive works as well as in simpler ones.

This all encourages investing in learning how to use modern machines and devices and adding staff equipped with knowledge and skills which are not only related to mining, electrical engineering and machine construction. Currently, the required competencies relate to fields such as: electronics, information technology, automation, telecommunications, robotics or mechatronics [3].

The activities of PGG S.A. aimed at improving the production process through mechanization and automation focus on the following areas:

- mechanization:
  - mine transport,
  - release and preparation works;
- building an environment conducive to process automation:
  - standardization of longwall equipment,
  - monitored pressures in powered support sections,
  - Energomechanical Supervision Center,
  - visualization and control of production processes,
  - wireless connectivity;
- automation:
  - central haulage control,
  - visualization and control of switchgear.

## 2. THE AREAS OF MECHANIZATION AT PGG

---

### 2.1. Mine transport

In general, transport is a set of activities consisting of moving goods in time and space using appropriate means of transport. Transport optimization is an important factor in the mine's production process; therefore, the tasks of managers include finding solutions to such problems as:

- optimization of transport routes,
- minimization of transport costs,
- selection of the appropriate type of transport,
- ensuring the continuity of the production process, minimizing disruptions in the supply process, timely and reliable material deliveries.

Mining transport is inextricably linked with the exploitation process. Moreover, we deal with the transport of materials, machines, devices, output and,

above all, people. This can be divided into three chains:

- horizontal transport on the surface, including loading of necessary materials and equipment in warehouses and their transport to the pit,
- vertical transport (pulling) through a mining shaft,
- horizontal transport from the pit at the bottom of the mine to the mining face and to other regions participating in the deposit exploitation [4].

#### 2.1.1. Transport of machines, devices and materials

In Polska Grupa Górnicza S.A., underground transport along the main transport roads and to face-walls with built-up routes is carried out by means of suspended railways. Moreover, shaft and departmental transport are supported with shunting tractors, with Polska Grupa Górnicza S.A. using 54 manoeuvring tractors in comparison to 28 in 2017.

#### 2.1.2. Crew transport

Work optimization is closely related to the implementation of numerous logistical advancements in its various aspects affecting improvement of the production process efficiency. Many of them allow the saving of time and energy expended by employees having to reach remote areas. Therefore, efforts are being made to modernize belt conveyors in the rapid transport of workers to and from distant workplaces. Currently, there are 28 conveyors adapted for the transport of people in the mines of PGG S.A, compared with 18 in 2019.

### 2.2. Release and preparation works

The size of the preparatory and access works has a significant impact on the mining capacity of individual hard coal mines. Ensuring adequate advance in face works is an important factor in the entire production process. Of particular importance from the economic and technical point of view is the performance of the release works without excessive advance and yet with great daily progress. For this it is necessary to carry out works with the use of roadheaders at optimal power for the given cross-sections of the excavation and the parameters of the excavated rocks.

Currently, gallery drilling at PGG S.A. is carried out in 85% with the use of roadheaders, while the remaining 15% of the work is carried out with the use of blasting agents. In 2017, this ratio was 78% and 22%, respectively. Depending on the size of the roadway support in which the excavation is to be drilled and the geological structure of the road in which the roadheader will be processed, the Company uses four classes of roadheaders as presented in Table 1.

Floor loaders are used when drilling the corridor workings with the shooting technique, where removing fragments of gangue and coal from the sidewalls and the ceilings required. These are self-propelled machines based on a tracked chassis with an electro-hydraulic drive, in which all control functions are performed hydraulically. Currently, PGG S.A. uses 49 floor loaders in access and support works.

**Table 1**  
**Percentage of individual classes of roadheaders working at PGG S.A.**

Roadheaders class by PGG	Engine power in the cutting head [kW]	Percentage [%]
A	min. 100	41
B	min. 130	33
C	min. 150	16
D	min. 200	10

An essential element in ensuring the continuity of the mine's production process is maintaining the already existing corridor workings in a technical condition, guaranteeing the required dimensions which will maintain appropriate airflow and communication for the transport of ore and materials. These works are performed using the kinds of floor loaders commonly used in Polish coal mining. They are used for floor collection, loading works in pavements, and pulling up materials in various places of the mining infrastructure [5].

Along with the progress, manufacturers provide more advanced solutions in face works using wheel drives. PGG S.A. uses two mining machines on a wheeled chassis with a combustion engine under the trade name ROBO-KOP. The mobile multi-purpose truck is used in corridor faces that are not equipped with electrical or pneumatic installations and used, among others, for transporting material and output.

### **3. BUILDING AN ENVIRONMENT CONDUCTIVE TO PROCESS AUTOMATION**

#### **3.1. Standardization of the equipment of longwall systems**

Polska Grupa Górnicza SA, on the basis of through its Zakład Remontowo-Produkcyjny, is implementing the standardization process of mechanized longwall supports, as well as for longwall face scraper conveyors and under-wall scraper conveyors.

##### **3.1.1. Standardization of mechanized longwall supports**

The standardization process of mechanized longwall supports is being carried out with regard to the structure of the support components and power hydraulics.

Zakład Remontowo-Produkcyjny PGG S.A. (Repair and Production Plant), based on the analysis of the needs of the mines for mechanized longwall supports, has developed three main geometric ranges of the supports' operation:

- 1.2–2.4 m,
- 1.5–3.5 m,
- 1.9–4.1 m.

The above division of the range covers 90% of the Company's needs.

##### **3.1.2. Standardization of longwall and under-wall scraper conveyors**

The standardization process of the longwall and under-wall scraper conveyors is carried out in relation to the structure of the gutters of the scraper conveyors.

Based on the property status analysis and the available technical solutions, two standards for longwall and under-wall scraper conveyors were defined, and the geometry parameters of the gutter were used in them.

Longwall and under-wall scraper conveyors:

- class 800,
- class 1000.

#### **3.2. Monitored pressures in powered support sections**

The deteriorating operating conditions make it difficult to use machines and devices in longwall systems

in a fully automated system. This forces the search for solutions that will guarantee the achievement of the assumed production rates while maintaining the maximum safety of the crew and the effective use of the machines during operation. In order to ensure the required safety in the operation process, it is necessary to secure the newly selected spaces and to ensure the proper support of the ceiling in the longwall workings. These requirements are fulfilled at PGG S.A. by using powered supports with a pressure monitoring system.

At the PGG S.A. mines, 22 pressure monitoring systems are used for monitoring the pressure in the piston cavities of the powered supports in both passive and active versions.

The passive system enables the visualization of pressure in the supports of the powered support, and a graphic and tabular form of the pressure changes in individual sections is presented based on these data. Meanwhile, an active system, like the passive one, allows one to fully visualize the pressure in the section stands and to automatically increase the pressure to the assumed value.

### **3.3. Ergomechanical Supervision Centers. Visualization and control of production processes**

The proper operation of machines and devices requires central supervision, which is carried out at PGG S.A. through the Ergomechanical Dispatching Centers on monitors and large-format synoptic boards on which information is presented graphically in the form of conventional pictograms, unit symbols, and using mostly backlit and digital displays.

Monitoring the course of the production process in a mine is one of the most important ways of obtaining information about events occurring in this process. This issue is significant concerning machines and devices operating in a given or automated mode, for which monitoring, registration, and subsequent reproduction of the actual parameters of the production process are vital. These data can be obtained directly from measuring devices, control devices, steering devices, or measurements performed by specialized mining services. Information from the monitoring of production processes is processed and archived directly at the collection point. Some of them are also archived in the domain programs of the SZYK 2 system and in the data, warehouse supervised

by Zakład Informatyki i Telekomunikacji PGG S.A. (Department of Information Technology and Telecommunications).

### **3.4. Wireless connectivity**

The mining of individual coal seams is increasingly deeper, with mining areas located at greater distances from the shafts. Such conditions make it necessary to look for and apply modern solutions in connection and communication in mines. The types of connection used so far, including in the mine underground railway – trolafeon connection using an electric traction slide wire, shaft connection using a hoist line or wired systems used in mine rescue are being systematically replaced by more modern wireless systems.

In underground transport systems, ensuring the connection between the operators of means of transport and the keeper is crucial to ensuring effective transport and the safety of people on the routes of transport. When conducting a rescue operation, it is necessary to ensure the people managing the operation at various levels and the rescue teams. In such situations, a reliable connection system guarantees effectiveness and safety.

New available solutions in the field of wireless connection increase the level of safety and facilitate and accelerate the work of mining crews, thus increasing their efficiency. PGG S.A. mines have underground and shaft wireless connection systems of nearly 113 km length based on radiating cables or antennas with access points (only 89 km in 2019). Due to the considerable pressure on the high degree of reliability of the designed devices, the currently manufactured devices are characterized by high durability and resistance to external conditions.

## **4. AUTOMATION AREAS AT PGG S.A.**

---

### **4.1. Central haulage control**

In recent years, the departure from dispersed control systems of belt conveyors in favour of systems for central haulage management has continued. Modern monitoring and control systems for mine operation in the vast number of cases take into account the operation of conveyors in terms of fluidity of the haulage, as well as their start-up and braking. Currently, the

Company's mines use over 100 belt conveyors using remote or central control (66 conveyors in 2019).

#### 4.2. Visualization and control of switchgears

At PGG S.A. the remote control of switchgear is still being implemented in order to ensure the desired results are attained. The only limitation in this aspect are related to implementation cost. Currently, there are over 49 switching stations with remote control in use.

### 5. CONCLUSIONS

Thanks to the mechanization and automation of production processes, combined with data processing, exchange and archiving, Polska Grupa Górnicza S.A. has become an enterprise using proven modern solutions.

It should be stated that increasing the level of automation and mechanization in hard coal production is necessary for maintaining the competitiveness of underground mining.

The key factors determining automation include ensuring an increase in production efficiency and the environment for underground mining – environmental conditions of natural hazards, legal restrictions on the adaptation of devices from other industries. The current personnel changes are of great importance. The declining human potential, primarily related to mining and knowing its specific nature, and a significant increase of the labour costs, generate greater emphasis on the implementation of new solutions, but at the same time, causes difficulties related to recruiting appropriately qualified employees.

In addition, the unique nature of mines and their threats determines the purposeful and individual approach to solutions that may be used in mining, a factor which may hinder and certainly slow down the modernization process of the broadly understood machinery park in hard coal mines.

According to one of the leading consulting companies, the market of automated technologies is growing at a rate of over 40% annually, and by 2027 it is expected to reach a value of over USD 25 billion. PGG S.A. aims to exploit the potential of automation but it is clearly discernible that the pace of the creation of proven modern mining industrial solutions is insufficient. This is undoubtedly a huge challenge for scientific-research units and managers responsible for the improvement of production and logistics processes in the mining industry.

#### References

- [1] Kicki J., Jarosz J., Sobczyk E., Saługa P., Dyczko A. (red. nauk.): *Materiały Szkoły Eksploatacji Podziemnej 2005*. Wydawnictwo IGSMiE PAN, Kraków 2005 (Sympozja i Konferencje nr 64).
- [2] Stankiewicz K., Jasiulek D., Jagoda J., Jura J.: *Rozproszone systemy sterowania maszyn i urządzeń górniczych*. *Maszyny Górnicze* 2016, 3: 54–66.
- [3] Gierlotka S.: *Rozwój elektryfikacji kopalń węgla kamiennego*. *Hereditas Minariorum* 2016, 3: 225–236.
- [4] Fuksa D., Wilkosz A.: *Organizacja transportu poziomego w systemie logistycznym kopalni węgla kamiennego*. *Logistyka* 2015, 4: 8850–8855.
- [5] Konsek R., Deja P.: *Nowe rozwiązanie układu zasilająco-sterującego górniczej maszyny mobilnej*. *Maszyny Górnicze* 2018, 4: 67–77.

RAJMUND HORST, M.Sc., Eng.

JAN ZDZIEBKO, M.Sc., Eng.

Polska Grupa Górnicza S.A.

ul. Powstańców 30, 40-039 Katowice, Poland

j.zdziebko@pgg.pl