

# The Possible Uses of Computer Tools in the Repair Management of Hard Coal Mines

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**Abstract**

Contemporary hard coal mines operate in increasingly demanding economic, technological, and environmental conditions. Maintaining the technical efficiency of mining machinery and equipment requires effective repair management.

The use of computer tools in this area allows for increased efficiency, improved safety, and optimized exploitation costs. This article explores the potential of using computer tools for repair management in mining plants. The authors focused on repair management in the exploitation process, especially the options for using CMMs (Computerized Maintenance Management Systems) in this process. The introduction of a CMMs class system in hard coal mines should ensure the continuity of the operation of the exploited machines and devices, allow a significant cost reduction as a result of increasing the time of the machines' use, and, what is associated with the latter, an extension of the machines' service life.

**Keywords**

CMMs system, computer tools, hard coal mines, repair management



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### ***Introduction***

In the era of energy transformation and rising excavation and extraction costs, hard coal mines are under pressure to improve their operational efficiency. One of the key areas affecting production costs and continuity is repair management – i.e., all activities related to maintaining the technical efficiency of machines, devices, and installations. Modern IT solutions are replacing traditional methods of planning renovations and inspections, providing better control, faster response to failures, and the ability to analyze data in real time (Krawczyk, 2022).

Striving to ensure better quality products in each one of their aspects, i.e., technical and functional parameters, by forcing the use of new technical and organizational measures. It is important to ensure constant supervision over the planning process, production, and the long-term sales policy, while using appropriate controlling methods and ensuring a steady increase in product quality, continuously utilizing available technical and organizational measures, including IT systems to supervise documentation (Trzop et al., 2024)

It is a basic requirement for competing in the market to provide high-quality output (products and services) at lower cost than the competition, as well as to use new production and organizational technologies. Both the surroundings of enterprises and the enterprises themselves are forced to operate more dynamically and plan for the future, which only intensifies the uncertainty and risk of the decisions made (Sujová et al., 2023; Toś et al., 2024).

Proper enterprise management, which enables the development of innovative products and thus profit, requires conducting research and analyzing the implemented innovations (Bołoz and Midor, 2018; Biały, 2025).

This justifies the need to assess the decisions made and the variants of the proposed technical and technological solutions, taking into account the various criteria for their evaluation. Making a decision – choosing one from many possibilities – requires advanced tools for collecting and processing data, then turning that information into knowledge used to analyze production and business processes.

The basis for efficient and effective repair management of existing technical systems in mining plants is the use of appropriate information systems (Frankovsky et al., 2020). This is particularly clear in the process of exploiting complex systems (for example, exploitation in hard coal mines), in which any information based on the decision concerns a very broad and varied range of issues. In this case, making rational decisions is possible only if we take into account the many aspects of this diversity.

This diversity of actions and the decisions associated with them necessitate managing data sets, that is, having the decision-making entity manage the full range of information about the objects and the exploitative processes carried out with them. Existing and functioning solutions in the form of IT tools can be helpful in this process. The tools used in this process are known as CMMs (Computerized Maintenance Management Systems) and cover the full range of tasks carried out as part of maintenance management. CMMs class systems support exploitative processes in the tasks of maintaining, repairing, and operating the systems covered by the system through extensive technical, organizational, and economic activities. CMMs class systems signal the need to complete service preventative maintenance, quantitative and timely protection of operating resources (tools, specialized equipment, consumables, spare parts) for the purposes of repair and maintenance work, quick reporting and taking actions resulting from the occurrence of emergencies, optimization and minimization of time necessary for service, and management of documentation of the tasks.

Research methods, including quantitative methods for analyzing statistical data and data from the technical documentation of the analyzed mine, and qualitative methods, have been used to develop this article. This article was based on a case study.

### **Review of computerized tools that can be used in repair management in mines**

Repair management in mines includes activities related to planning and implementing technical inspections, repairing and modernizing mining machines, managing replacement parts, monitoring equipment consumption, and preventing failures (Nowicki, 2016; Skoczyński, 2017). Repair management is therefore crucial for (Bartoszek and Michalak, 2019):

- Production continuity – machine failure may cause the entire technological production line to stop, resulting in significant losses.
- Work safety – devices in poor technical condition may pose a threat to the miners' lives and health.
- Rational resource management: By planning inspections and renovations, unnecessary element replacements or expensive emergency repairs are avoided (Saga et al., 2011).
- Meeting legal and environmental requirements – consistent documentation of repairs and technical control registers is required by mining law.

To complete the above-mentioned tasks, mine managers may use a number of computer tools available to them, which have been successfully utilized in other industries. These include CMMs, ERP systems, computer

simulations, 3D modeling, and monitoring of technical condition (IoT) (Wojciechowski, 2015; Kaźmierczak, 2010; Pawłowski and Zawisza, 2018; Bołoz, 2022; Dudek, 2025).

CMMs systems (Computerized Maintenance Management Systems) enable:

- The registration and analysis of operational data.
- The planning of periodic inspections.
- The control of the implementation of renovation tasks.
- Conducting the history of repair and usage of parts.

In the context of the mine, this system enables, among others:

- The creation of electronic cards for the machines, including their review history, repairs, and failures.
- Automatic reminders of upcoming periodic inspections.
- The analysis of runtime efficiency (e.g., MTBF – Mean Time Between Failures, MTTR – Mean Time To Repair).
- Creating reports and repair schedules.
- Assigning tasks to technicians and monitoring work progress in real time.

ERP (Enterprise Resource Planning) systems are complex systems designed to manage an enterprise's resources. In the field of repair management, they enable the integration of technical data with data from warehouses, finance, and human resources. They allow for planning renovations, with special consideration of the availability of spare parts and human resources.

They automate the procurement of materials for repairs and ensure full control over renovation costs – you can analyze the planned vs. actual budgets.

As part of integrated ERP systems, repair modules cooperate with storage, financial, and logistics management, enabling:

- control of renovation costs,
- replacement of spare parts,
- reporting the technical condition of the equipment.

Computer simulations and 3D modeling allow:

- analysis of machines in mine conditions,
- failure predictions,
- optimization of renovation schedules.

CAD/CAM technology and simulation tools help create three-dimensional models of mining machines and installations, which facilitates diagnostics. Failure scenarios are simulated, and their potential effects are analyzed. The arrangement of machines and their route in the mine is optimized. The modernization is also planned and "tested" digitally (Kovanic et al, 2025a; Kovanic et al, 2025b, Kovanic et al, 2021).

Monitoring the technical state (Predictive Maintenance) using IoT sensors and data analysis, in turn, enables ongoing tracking of devices' operating parameters, detection of technical wear symptoms, and service decisions based on the actual technical condition of the machines.

Predictive maintenance systems are based on:

- Use of sensors (vibrations, temperature, pressure) for ongoing tracking of machines (Pivarciova et al., 2019).
- Analysis of data from sensors in real time using AI algorithms or machine learning.
- Early detection of irregularities enables planning repairs before a failure occurs.
- Reducing unplanned downtime and increasing device operational availability.

### **Introduction to CMMs computer systems**

CMMs are generally the coordinated processing of information, creating a data set, conditioned by a constant, logical ordering of its parts, to maintain the exploited objects in a state of fitness. Subsystems forming the CMMs system (Loska and Kot, 2000) enable information processing in the following subsystems:

- Exploited objects subsystem. The exploited objects subsystem contains information on all exploited objects (machines and equipment) and their interrelationships (by location mode, e.g., mechanical, electrical, electromechanical, hydraulic, pneumatic, etc.), characteristics, and current technical condition. Exploited objects are most often spread into the hierarchical structure of assemblies, subassemblies, and parts. The essence of such a hierarchical structure is to identify its components clearly. A given component (parts, assemblies) can have only one parent component.
- Service planning subsystem. The service planning subsystem contains information to support the planning and execution of cyclical preventive and maintenance repairs. It contains work plans, including individual

service activities, with detailed chronoanalyses for each. The subsystem also allocates and books employees with appropriate qualifications, as well as books spare parts and specialized tools. The service implementation subsystem uses information from the service planning subsystem.

- Service implementation subsystem. The tasks of the service implementation subsystem include approving the task assignment, implementing and controlling cyclical technical services, and settling costs for work, spare parts, materials, and tools actually used.
- The subsystem of spare parts and purchases. The subsystem of spare parts and purchases manages spare parts used in the course of service by booking them, issuing from a warehouse or cache warehouse, allows for the supervision of reserve parts (including within the technologically and economically justified limits, minimum-maximum), as well as allows for the automatic implementation of retail procedures and the completion of inventory transactions.
- The schedule subsystem. The schedule subsystem generates service task schedules based on the availability of exploitation objects and staff. It contains technical and organizational data regarding supported exploitation objects.

### **CMMs-class systems – FUNCTIONS**

The functions of a typical CMM class system can be presented as task areas (Loska, 2004). These areas include:

- Management of technical facilities.
- Planning and implementation of repair and maintenance work, as well as management of service and repair staff.
- Management of spare parts and consumables, as well as tools and specialized equipment;
- Safety management of repair and maintenance work.
- Managing the costs of repair and maintenance work.
- Management of maintenance, operations, and maintenance manuals.
- Documenting repair and maintenance work.

### **Management of technical facilities**

One of the most important elements of CMM-class systems is the management of technical facilities. The CMM system contains information about the current technical condition and the characteristic features of the operated objects. This includes, among others, information such as:

- Construction of technical facilities within the hierarchical structure.
- distribution of individual technical facilities in the structure of the enterprise and the existing connections between these objects, taking into account the type, nature, and time of occurrence in a specific setting.
- History of exploitative events in the form of a set of planned and emergency applications, a detailed description of each event, and an analysis of the reasons for each of these events occurring.
- Diagnosing and monitoring selected work parameters of technical facilities, including the limits and measurement values at selected measuring points, enables early detection of incorrectly operating objects, enabling specific decisions and actions to prevent failure.
- "Counter" of the technical facility's work, enabling one to determine the dates of service based on the actual working time of the object.
- Costs resulting from the operation of technical facilities (especially for services and repairs).

### **Planning, implementation of repair and maintenance work, and management of service staff**

Tasks related to planning, preparation, implementation, and control of repair services are carried out while utilizing documents called task assignments.

Planning tasks. The preparation, implementation, and control of repair services are carried out through documents called task assignments, work assignments, or labor assignments. We can extract two elements, planning and implementation.

In CMMs class systems, the planning of repair and maintenance works is carried out in one of three variants, namely:

- Based on calendar time.
- Based on the amount of work performed.
- Based on data from diagnostic measurements.

Planning tasks using labor assignments requires determining the deadline for completing the order, the scope, the order of tasks to perform, and all participants and components of the service assignment. In particular, it applies to the following plans:

- work, i.e., a list of: activities, repair and maintenance work, materials and spare parts, tools;
- safety, which includes threats, precautions, and procedures to eliminate them.

The implementation of tasks includes the following procedures:

- Supervision over the correct performance of the service and repair, i.e., approving the scope of work to be done, tracking the implementation of tasks, approving the correct performance of tasks, and settlement.
- Conducting post-construction analyses – failure analysis, economic analysis.

In most CMM class systems, the management of service and repair staff includes:

- Collecting information about employees, which includes: personal data, workplace locations (especially useful in the case of enterprises with large areas), qualifications, special skills, work calendar, and individual salary grade.
- Reservation of employees for planned tasks.
- Direct allocation of employees for priority tasks.
- Tracking the location and ranges of tasks by employees.
- Determining employment costs based on time actually spent working and hourly rates.
- Management of the work of external entities (foreign companies).

### **Management of spare parts and consumables, as well as tools, and specialized equipment**

To effectively manage spare parts and consumables as part of CMMs class systems, the following three goals should be met:

- quantitative, that is, maintaining the amount of spare parts and consumables in the warehouse by preventing excess or deficiency of storage;
- qualitative – preventing, issuing, issuing damaged or outdated spare parts, and exploitation materials;
- valuable – conducting an effective operational policy in terms of costs related to the acquisition, storage, and flow of spare parts and consumables.

The above goals can be achieved by supporting basic warehouse management activities, among which we can distinguish:

- booking spare parts for the needs of specific service and maintenance activities;
- directly issuing and storing spare parts;
- informing about the need to buy missing parts;
- implementation of purchasing procedures.

In order to carry out the above tasks, methods related to quantitative and valuable storage are used, among which are:

- The Economic Amount Ordered Method – consisting of determining the individual size of orders.
- The Point of Further Orders Method – consisting of determining the limiting value of spare parts or exploitation materials in the warehouse, which is the basis for placing another order.

In some CMM class systems, managing tools and specialized equipment is a separate management area. This area relates to the management of tools, which clearly influences the cost of repair and maintenance work. The tasks of this area include:

- collecting information about the tools and specialist equipment, including information such as technical data, location of the storage site (especially useful in the case of large enterprises spanning vast territories), and costs associated with use;
- booking tools and specialist equipment for planned tasks;
- issuing tools and specialist equipment for priority tasks (without initial booking);
- tracking places and ranges of the tasks' implementation, especially considering tasks utilizing specialist tools and equipment;
- costs of use based on time worked and the hourly rate;
- management of tools owned by external entities.

### **Managing the safety of the repair and maintenance works**

Safety is one of the most important aspects of the exploitation of technical objects, as it concerns both users and workers performing repair and maintenance work. CMMs class systems include elements that enable the safe completion of all repair and maintenance work. In this case, supporting the management of safety depends on:

- Gathering information on threats, safety measures, hazardous materials, and procedures for eliminating threats and hazards, supplemented with quantitative measures of the appropriate parameters (such as the risk level).
- Creating safety plans as complex procedures to prevent hazards threatening the workspace during repair and maintenance work.

- Connecting the elements of the safety plans with the exploitation objects, taking into consideration the appropriate work safety procedures for the relevant and individual facilities.
- Connecting the elements of the safety plans with the repair and maintenance works, considering the appropriate procedures of safe work as part of the procedures of repair and maintenance works.

#### **Managing the costs of repair and maintenance work**

Supporting repair and maintenance tasks for the CMMs class systems is most often carried out based on issued work orders. Therefore, the costs included in the orders are treated as costs of realizing the repair and maintenance works. The costs of the order include:

- labor costs, which include hours worked and registered by the maintenance department, including the costs of the places where those costs were created;
- material costs, including the costs of using materials and spare parts, together with the costs incurred for obtaining, preparation, storage, and transport of these materials and parts;
- costs of tools and specialist equipment, which includes the costs of using and renting those tools, the use of which generates costs;
- foreign costs (also called service costs), which arise from the use of services and benefits from foreign companies or service providers.

The above costs are charged to the exploitation object for which the order is issued, increasing the overall cost of its operation.

#### **Management of maintenance, operations, and maintenance manuals**

Information resulting from maintenance manuals, as well as operations and maintenance manuals, is of significant importance in the implementation of service and repair works. It affects the quality and efficiency of the assisted activities. It is possible to enter and process data in the form of:

- Maintenance manuals of individual facilities.
- Descriptions of the object's order of operations, as well as other requirements (such as forms and documents necessary to carry out specific tasks).
- Links to internet or intranet websites containing important information relevant to the implementation of tasks.
- Numerical maps allowing for the location of individual technical facilities in a specific area (e.g., location of the network of individual installations: water, compressed air, power supply, etc., in underground workings).

#### **Documenting repair and maintenance works**

The process of documenting repair and maintenance work allows the results of the tasks to be presented. A typical package of reports and analyses, both text and graphics, can be assigned to three classes, namely:

1. Maintenance costs.
2. Availability.
3. Efficiency of maintenance organization.

The first class of reports and analyses provides a cost profile of maintenance by organizational unit (production) or cost center.

The second class of analyses and reports allows you to obtain the availability of operating objects (working times and readiness to work relative to the time of stop) for individual organizational (production) units or cost centers.

The third class of reports and analyses takes into account the manner and scope of the organization's use of maintaining the movement of assumptions and standards adopted by the organization, related to the planning, preparation, and implementation of services and repairs.

### **Comprehensive mechanization of the cutting sequence**

The CMMs class system is most often used for management in the mine, hence the detailed description of the former in the context of the cutting sequence later in this article.

As part of the cutting sequence, one can distinguish the following stages:

- The cutting process.
- Horizontal transportation.
- Vertical transportation.

Following the cutting sequence allows the conclusion to be made that it is a serial system. The failure of one of the mentioned links will cause the other elements of the sequence to "turn off".

To control and optimize the cutting sequence, it is recommended to integrate a computer system into the cutting process and the specific tasks. The above system should be an integral part of the computerized system of mine management.

Improving extraction efficiency is largely about maintaining the movement of the mine's technical system. At the same time, there is a strong need to improve the maintenance system's efficiency, thereby increasing the readiness of the exploited systems and reducing costs.

Optimization of renovation processes and modernization of complex systems, e.g., energy-mechanical systems, requires an effective tool that comprehensively supports the implementation of large investments, usually carried out during an active mining process.

The best tool for controlling and optimizing this type of task is a specialized repair management module integrated into the mine management computer system. Its use will also improve work safety and thus reduce the costs necessary to ensure safety.

At present, renovation processes in mining enterprises are mainly organized through traditional methods, and many company entities and external companies take part in maintenance and repair activities. Analysis of generic costs, illustrated by Jastrzębska Spółka Węglowa S.A. (JSW S.A.), shows distinct cost dynamics (Wróbel, 2003).

Table 1 presents the percentage share of the components of individual costs at the bottom of the mine in a year-by-year comparison. The diverse level of generic costs at the bottom of the mine forces detailed analyses and the determination of the underlying causes of specific costs.

Tab. 1. Increase in costs by nature at the bottom of the mine

Type of costs		Year 1	Year 2	Dynamics		
				Year 1/Year 2	Year 3	Year 2/Year 3
salaries/wages	thousand PLN	220.247	240.558	109.2%	263.501	109.5%
	%	57.6	58.0	100.6%	59.4	102.4%
materials	thousand PLN	26.136	38.330	146.7%	45.640	119.1%
	%	6.8	9.2	135.1%	10.3	111.3%
energy	thousand PLN	16.472	22.081	134.1%	28.272	128.0%
	%	4.3	5.3	123.5%	6.4	119.7%
amortization	thousand PLN	75.119	60.650	80.7%	48.050	79.2%
	%	19.7	14.6	74.4%	10.8	74.1%
repairs	thousand PLN	17.461	16.649	95.3%	20.459	122.9%
	%	4.6	4.0	87.9%	4.6	114.9%
other costs	thousand PLN	26.632	36.408	136.7%	37.686	103.5%
	%	7.0	8.8	126.0%	8.5	96.8%

Table 1 strongly suggests a significant cost increase in the second year compared to the first year, as noted in the renovation costs (a 23% increase at a comparable level of fixed prices). That is, outside of energy costs, the greatest increase is in the group of generic costs. Having considered the increase of installed power in the drum longwall shearers, the exploitation of coal seams of class III workability (very difficult to cut) (Biały, 2004), as well as the 'age' of the cutting machines, one can assume a further dynamic growth of costs in this group of generic costs. As of today, Polish hard coal mines have not established a single system for managing the operations of mining machines, neither during exploitation nor during renovation.

This system should include (Winkler and Loska, 2004):

- The observation, registration, and analysis of individual activities.
- The plan of activities.
- The method of collecting information about machines and devices.
- The method of establishing the scope of the service work is between the user and the manufacturer.
- The development of the appropriate competences of employees performing maintenance activities.
- Collecting and processing information in the field of maintenance.

Maintenance tasks for mining machinery are carried out by mine services and external companies. For external companies, they are usually manufacturers of a given machine or device.

Each machine or device in the mine that is subject to periodic repair and maintenance works may be properly located in the repair structure. Figure 1 shows a block diagram of the repair structure.

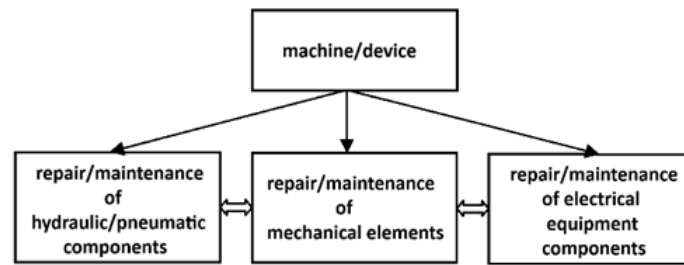


Fig. 1. Block diagram of the repair structure

The following mine branches take part in the repair activities.

The mechanical department of the wall operating devices. The work of the branch includes:

- Maintenance and upkeep of devices in the field in constant physical readiness.
- Renovation and maintenance of devices in the walls (lining, winning machines, hauling in the wall – chain-and-flight conveyor).
- Conservation of haulage devices outside the faces.
- Maintenance of material transport equipment in mining districts.
- Maintenance and repair of drainage, high-pressure, fire, and compressed air pumps, maintaining the pipelines in good condition, as well as their assembly and disassembly in the area of mining districts.
- Renovation and regeneration of the engine chamber's basic machine parts and hydraulic elements.

Mechanical Department of Power Hydraulics. The tasks of this department include:

- Maintaining devices of the mechanized housing plumbing lining on their wall faces, which in turn maintains the working support of the mechanized linings.

Mechanical Department of Preparatory and Support Works. The tasks of this department include:

- Maintenance of devices in development headings, keeping them in constant readiness.
- Renovation and maintenance of machinery in the heading faces.
- Proper equipment and preparation of drifts.
- Installation of fire, compressed air, and drainage pipelines in heading faces.
- Installation of mined rock haulage and transport of material for drifts.

Main Haulage Mechanical Department. This department serves other departments in the fields of service, maintenance, and upkeep of existing haulage machines, including:

- the drives and return stations of the belt conveyors of the material haulage,
- pumps and drainage pipelines in the appropriate region,
- assembly, disassembly, and maintenance of fire and compressed air pipelines,
- cooling and transportable compressors in the appropriate region.

Electrical Department of Traction and Pit Supply. This department is imperative for ensuring the continuous flow of traffic at the bottom of the mine by supplying machinery, underground equipment, and electric traction.

Shaft Machinery and Main Drainage Department. This department is assigned:

- service, maintenance, and maintenance of shaft devices,
- service, maintenance, and maintenance of main pumps,
- service, maintenance, and maintenance of main fans.

Coal Preparation Repair Mechanical Department. The department's scope of responsibilities includes:

- Maintenance and upkeep of coal preparation plants.
- Maintenance and upkeep of haulage traction.

Mechanical Workshop and Essential Surface Facilities Department. The department services other departments in the field of:

- Repair of essential mining devices.
- Operation and maintenance of the machines comprising the surface facility providing mining emulsion (Jakubovicova et al. 2015).
- Renovation and maintenance of the ventilation station responsible for the main ventilation of the mine.
- Renovation and maintenance of compressors and auxiliary equipment.

The following mine branches take part in the maintenance activities (for the upkeep of maintenance):

Excavation Department.

This department's tasks include the daily service and maintenance of machinery used to haul coal in the ward, namely chain-and-flight conveyors, wall conveyors, sub-wall conveyors, and belt conveyors for the main haulage.

#### Department of Preparatory Works.

The tasks of this department include the assembly, daily operation, and maintenance (or liquidation) of the machinery for coal haulage, the machinery for transporting materials, and the ventilation machinery for the mining face.

For the department of production preparation, all repairs of damaged machines are carried out by outside contractors, ensuring constant internal service and maintaining devices in constant readiness. Service and maintenance of devices related to direct power supply to energy, drainage, and ventilation (from the mine's side) is also required for these branches.

Electrical Department of Exploitation Works and Electrical Department of Preparatory Works. The department's tasks are: constantly ensuring the electricity supply and ongoing maintenance of electrical equipment for longwall shearers, heading machines, haulage devices, and transport. External companies also carry out services and perform repairs.

### Analysis of the failure rates of the cutting sequence

This article analyzes the failure rate of three mining walls in one of the coal mines of the Polish Grupa Górnicza S.A. (PGG S.A.):

- IA-E1 wall in seam 620/1-2;
- Wall XI-W1 in seam 703/1;
- Wall XII-W1 in seam 713/1-2.

Table 2 presents the technical equipment for the walls and haulage, analyzing mining walls in one of the mines of Polska Grupa Górnicza S.A. (PGG S.A.) during exploitation.

*Tab. 2. Technical equipment of the analyzed walls*

Coal Longwall	Technical Equipment of the Coal Longwall			Technical equipment of the haulage		Number of mining shifts
	Type of powered support	Coal face conveyor	Coal shearer	Coal conveyor	Conveyor belts	
Ia-E1 seam 620/1-2	METROL 18/37 POz/MR – 125 mine support section FAZOS 15/31 Oz – 16 mine support section FAZOS 12/28 Oz – 10 mine support section FAZOS 15/31 – BSN	Rybnik 225/750 2 x 200/65k W + 200/65k W	KGS-440/2B 2 x 132 kW + 60 kW diameter of the cutting drums ø 1800 mm	Rydułtowy II 2 x 132 kW + splitter DU2-P6	Gwarek 1000 2 x 100 kW PTG 1000 90 kW PTG 1000 55 kW PTG 1000 55 kW	252
XI-W1 seam 703/1	GLINIK08/26 OzK – 123 mine support section METROL 12/26 Oz/MR – 34 sekcje METROL 12/26 Oz/MR 2 mine support section	Halbach-Braun HB 3E74VS3D 2 x 200/65 kW + 250/85 kW	KSW-460 N 460 kW diameter of the cutting drums ø 1500 mm	Rydułtowy II 2 x 100 kW + splitter DU2-P6	Gwarek 1000 2 x 75 kW Gwarek 1000 2 x 90 kW PTG 1000 90 kW	162
XII-W1 seam 713/1-2	METROL 08/28 POz/MR 1 mine support section FAZOS 15/31 BSN – 2 mine support section FAZOS 15/31 Oz – 132 mine support section METROL 15/38 POz/MR – 18 sekcji METROL 15/38 POz/MR 2 mine support section	Halbach Braun 4HB – 260 2 x 250/85 kW + 250/85 kW	KSW-460 N 2 x 200 kW + 60 kW diameter of the cutting drums ø 1500 mm	Rydułtowy 2001 2 x 132 kW/45 kW + splitter DU2-P6	Gwarek 1200 2 x 75 kW MIFAMA 1200 2 x 90 kW	279

Table 3 presents the analysis results. As clearly indicated (Table 3), the "wall" failure rate is definitely greater than haulage-related failure rates. The summary average failure rate for each wall oscillates around 14%, resulting in significant downtime and undoubtedly causing significant monetary losses and increased operating costs.

*Tab. 3. Failure rate of drum longwall shearers and haulage*

Coal Longwall	Coal wall				Haulage of spoil				Total failures %	Number of mining shifts	Number of "failure" changes
	Mechanical failures	Electrical failures	Mining failures	Together	Mechanical failures	Electrical failures	Other	Together			
Ia-E1 seam 620/1-2	10.30%	0.67%	0.06%	11.03%	1.24%	0.27%	0.58%	2.09%	13.12%	252	33
XI-W1	6.72%	2.99%	3.82%	13.54%	0.50%	0.19%	0.45%	1.14%	14.68%	162	24

seam 703/1											
XII-W1 seam 713/1-2	6.52%	3.14%	0.72%	10.38%	1.54%	1.01%	0.57%	3.11%	13.49%	279	38

The drum longwall shearer is characterized by a significant failure rate (Table 4).

Tab. 4. Complex failure rate of the shearer

Coal Longwall	Coal shearer	Total failure times [min]	Breakdown time of coal shearer [min]	Percentage share %	Number of mining shifts	Number of changes in coal shearer "failures".
Ia-E1 seam 620/1-2	KGS-440/2B	12925	7455	58	252	28
XI-W1 seam 703/1	KSW-460N	12650	4290	34	162	22
XII-W1 seam 713/1-2	KSW-460N	7350	3155	43	279	29

The overall breakdown failure time, the percentage share of the shearer failure, ranges from over 30% to almost 60%. The above failures exclude the entire cutting process for the exploitation from mining changes 22 to 29.

### Selecting and implementing CMMs in hard coal mines

In hard coal mines, where a large number of machines and devices operate under extreme conditions, implementing CMMs is not only beneficial but also necessary to ensure continuous operation.

When implementing the CMMs system in a mining company (mine), in addition to the technical assessment of individual systems, it is also necessary to:

- Recognize available IT measures in the enterprise, including but not limited to computer networks, software, databases, as well as computer equipment and operating systems, with technical parameters required by CMMs systems.
- Take into account the integration of the implemented CMMs system with existing IT systems in mining enterprises (for instance, payroll, human resources, storage management, etc.).
- Determine the structure of technical information circulation in a mining enterprise at the level of the mine's maintenance services and their connections with the parent structures (both internal and external).

Points A and B refer to the mine's IT equipment and will not pose a problem during implementation. The mines in the discussed range are already computerized, and adding another module to the existing IT system is feasible from an IT perspective. Point C is the basis of the CMMs system implementation strategy.

The implementation of CMM systems in mines should start with a detailed description of the mutual connections between the existing technical means that participate in the mining process, with the possibility of later adaptation to the entire technical structure of the mine (Biały and Bobkowski, 2004; Bartoszek and Michalak, 2019).

Based on the failure analysis carried out in this article, it can be assumed that the first stage of the CMMs system implementation in the mine should include the technical equipment for the cutting sequence covering the wall complex, haulage, and mass haulage to the mining shaft(s).

The remaining stages should include:

- The technical equipment of the preparatory departments, including the haulage,
- The technical equipment of the mining shafts' devices and main drainage devices,
- The technical equipment of the ventilation devices,
- The processing plant.

In an order dependent on local preferences.

The above remarks apply to implementing the CMMs system in individual mines. Leading CMMs systems (for instance, MAMIMO from MRO Software) can cover many enterprises' plants across different locations (management of distributed organizations). This function enables centralizing or decentralizing the location of information collection and processing per the company's strategy within a single database (Fig. 2).

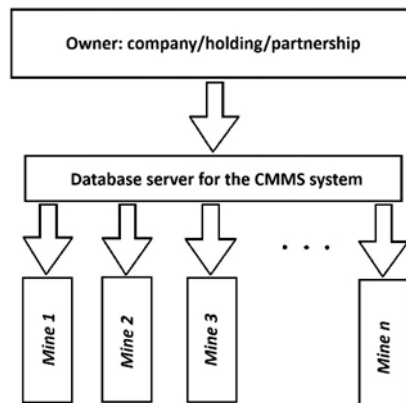


Fig. 2. Management of distributed organizations

As part of, for example, Polska Grupa Górnicza S.A. (Polish Mining Group), Południowy Koncern Węglowy S.A. (Southern Coal Syndicate), or Jastrzębska Spółka Węglowa S.A. (Jastrzębska Coal Company), which are the owners of hard coal mines in Poland, it will be possible to coherently manage work for all dependent organizations included in their composition.

The system allows you to define any number of organizations /or plants and to choose the management method at the level of the company, organization, branch, separately in relation to organizational and economic assumptions (accounts, base currencies, financial periods) and operational data (cooperators, taxes, task assignments, etc.). This will allow for more efficient management of the equipment that is part of the property, spare parts, human resources, and external companies working for the Spółka Górnicza (Mining Company).

### CMMs system – MAXIMO from the MRO software company

One of the CMMs systems used worldwide, as well as in Poland, is the MAXIMO system of the American company MRO Software.

MAXIMO enables efficient management of individual elements of the company's renovation system, from preparing work orders to planning work, employment planning, and purchasing parts and replacement components. This allows for proper storage management, taking into account the necessarily low reserves of parts and components.

Employees of renovation services can effectively and quickly record any damage to machinery in the system database, as well as the time of downtime, taking into account all events, including both repetitive and random ones. This allows a thorough diagnosis of the operational system's condition and failure rates, making it much easier to decide on its renovation or replacement.

### Summary

The use of computerized tools in the renovation of hard coal mines is a key element of the mining industry's modernization strategy. These tools not only allow greater savings and increased efficiency but also improve machine safety and reliability. The development of these tools will be increasingly integrated with the automation and digitization of mining processes.

Computer support for repair management is one of the key elements enabling the digitization of the mining industry. Thanks to modern IT systems, it is possible:

- to better manage the life cycle of devices,
- to reduce downtime and repair costs
- to increase operational safety in difficult working conditions.

In the future, the development of technologies such as artificial intelligence, the Internet of Things (IoT), and the cloud will further expand the possibilities for supervising and optimizing mine performance.

The sector of hard coal mining recorded a net loss of 11.06 billion in 2024, against a net profit of 4.8 billion a year earlier, as the data published by the Katowice branch of the Industrial Development Agency (Agencja Rozwoju Przemysłu) suggests. Coal sales revenues were a third lower than the year before. This data shows that any necessary actions to reduce production costs in this sector must be carried out.

The use of the CMMs class system brings significant benefits that translate into lower maintenance service costs.

CMMs class systems are often implemented in businesses seeking a specific certification, most often in quality, security, or environmental fields. Hence, technical solutions are directed to support activities that allow ordering, documenting, and proper conduct of all tasks according to the rules and guidelines stemming from relevant standards, such as:

- Quality management according to PN-EN ISO 9001:2015
- Environmental management according to ISO 14001:2015
- Work safety management according to PN-EN 45001:2024.

The MAXIMO system is characterized by high flexibility, work effectiveness, and functionality. The MAXIMO meets a set of requirements related to maintaining the standards of the ISO 9000 series. MAXIMO is at the forefront of management programs for machinery and equipment, thanks to its extensive implementation worldwide across various economic sectors, including mining, metallurgy (chemical, coke), paper, electric, machine, and energy. Reports of the independent consulting companies of Gartner Group confirm this. Inc. ©.

One should also pay attention to the challenges that appear when attempting to implement the CMMs system. Without a doubt, this includes the crew's resistance to the CMMs system, often stemming from being accustomed to paper documentation, staff shortages in IT and maintenance departments, difficult working conditions, initial investment costs, and the complexity of integrating the CMMs system with existing systems.

Despite these difficulties, one should underline the benefits of this system. These are primarily the reduction of renovation and downtime costs, the optimization of maintenance work, the constant supervision over the timeliness of the inspection and legalization of devices, the easy access to technical data and repair history in real time, compliance with the provisions of (PGG, WUG and OHS), as well as the possibility of reporting and analysis of KPI indicators (for instance, MTBF, MTTR).

According to the conducted studies, users of the MAXIMO system have achieved the following measurable benefits (Biały, Bobkowski, G. 2004):

- increasing work efficiency from 10 to 20%,
- reduction of warehouse inventory to 30%, and in some cases, even the liquidation of warehouses,
- reduction of emergency downtime by 20% (and more),
- increasing the durability of machines and devices to 10%,
- Increase in production capacity from 20 to 30%.

However, it should not be forgotten that achieving the above-mentioned quantities is not implemented "automatically" upon the decision to buy and implement the system. Such a system should be rationally:

- chosen;
- implemented;
- used.

Only the total implementation of these three values guarantees modern management of the technical system, and thus an improvement in the efficiency of technical facilities.

The implementation of CMM systems in Polish hard coal mines increases their competitiveness by improving operating efficiency, reducing costs, increasing safety, and ensuring better resource use. In conditions of growing economic and regulatory pressure, such solutions offer a market advantage in both the national and international contexts.

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