

Witold BIAŁY
Silesian University of Technology
Faculty of Management and Organization
Institute of Production Engineering

Grzegorz BOBKOWSKI
Silesian University of Technology
Faculty of Mining and Geology
Institute of Mining Mechanisation

APPLICATION OF COMPUTER SYSTEMS IN SUPPORTING MAINTENANCE POLICY IN MINING INDUSTRY

Summary. Continuous production maintenance in mining industry (coal mines) results in high production costs. Well-known computer systems supporting machine and appliances exploitation as well as traffic control in factories have been currently broadly applied in a variety of industry branches.

Therefore introduction of these systems in mining industry operations seems inevitable. CMMs class system introduction in mining industry should provide continuous operation of machines and appliances and result in decrease of variable costs of the company due to extended operating time of the devices. In terms of a coal mine, this time savings will result in loss cuts as a result of machine delays.

Applications of computer systems supporting the maintenance policy in mining industry have been presented.

Keywords: computer systems, maintenance policy, mining plant

WYKORZYSTANIE SYSTEMÓW KOMPUTEROWYCH DO WSPOMAGANIA GOSPODARKI REMONTOWEJ ZAKŁADÓW GÓRNICZYCH

Streszczenie. Zapewnienie ciągłości ruchu w zakładach górniczych (kopalniach węgla kamiennego) generuje wysokie koszty produkcji. Komputerowe systemy wspomagające zarządzanie eksploatacją maszyn i urządzeń oraz utrzymaniem ruchu w przedsiębiorstwach na dzień dzisiejszy znalazły szerokie zastosowanie w wielu gałęziach przemysłu. Dlatego też nieuchronne wydaje się wprowadzenie tych

systemów do obsługi zakładów górniczych. Wprowadzenie systemu klasy CMMs w zakładach górniczych powinno zapewnić ciągłość pracy eksploatowanych maszyn/urządzeń, a tym samym obniżyć koszty zmienne przedsiębiorstwa w wyniku wydłużenia czasu pracy tych maszyn/urządzeń. W przypadku zakładu górnictwa pozytywnym skutkiem tej oszczędności czasowej będzie ograniczenie strat spowodowanych przestojem maszyn.

Przedstawione zostały możliwości zastosowania narzędzi komputerowych do wspomagania gospodarki remontowej zakładów górniczych.

Słowa kluczowe: komputerowe systemy, gospodarka remontowa, zakład górniczy

Introduction

The technological breakthrough of recent years has caused a significant concentration of coal production. At the moment the only technology of coal mining in Poland is the longwall system. The number of longwalls has been reduced significantly (by 40%, i.e. by over 400 longwalls in 1995 alone) and the ones with the highest yield have been left in operation. Longwalls with a 3000-5000 t/day and more have appeared in Polish coal mining industry.

The following factors made it possible:

- the introduction of a new organizational structure of coal mines, which significantly improved work organization,
- increased efficiency of technological processes due to machines and devices of new generation used in the output production and haulage.

Mining technical systems are very complex, are used over large areas and their work area is restricted by the size of underground headings.

The introduction of coal mining concentration led to an increase in the power of longwall tumble coal miners – the ranges of power used in these machines are often between 800 and 1000 kW or more.

The key purpose of operation management is to ensure uninterrupted operation of the machines and devices used. Disruptions (e.g. due to a breakdown of a machine) cause enormous financial losses. Consequently, funds should be allocated for the purpose of improving this aspect of an enterprise's operation.

Machines/devices which are elements of technical systems used in the production process are subject to gradual wear and tear. An early assessment of the condition and the amount of wear and tear of a machine/device prevents breakdowns and necessary repairs. The use of the stock of machines/devices to its full capacity (working in several shifts) requires modern production organization, using the employees' work more efficiently, motivating them appropriately etc, but also proper maintenance should be provided i.e. preventive measures and repairs to ensure the operation of the devices.

Using the machines/devices according to their intended use and within the limits of their technical parameters and an appropriate repair management mean that the wear and tear processes and the necessary repairs can occur at regular intervals. These processes when repeated constitute the maintenance cycle, which is the basis for maintenance work planning.

Maintenance management aims to restore the operability of a given machine/device through planning repairs of different types and extent. The repairs can be divided into routine and emergency ones. A repair can be done by replacing a part or a subassembly using a standard or periodic post-inspection method.

1. Maintenance management in coal mines

At the moment there is no system in place in Polish coal mines to standardize the mining machine operation management system¹ either in terms of the machine/device operation processes or in terms of repairs.

Specialist services are responsible for managing the operation of mining machines. These can be both own and outsourced services. The companies working on the outsourcing basis are usually the manufacturers of the given machine/device.

All the machines/devices in coal mines, which are subject to periodic maintenance and repair works, can be found on the repair structure block diagram (fig. 1)²

¹ Biały W., Bobkowski G.: Awaryjność górniczych systemów technicznych. Zeszyty Naukowe Politechniki Śląskiej, seria: Organizacja i Zarządzanie, z. 22, Wydawnictwo Politechniki Śląskiej, Gliwice 2004; Biały W., Bobkowski G.: Możliwości wykorzystania narzędzi komputerowych w gospodarce remontowej kopalń węgla kamiennego. Mechanizacja i Automatyzacja Górnictwa 2005, nr 4 (411); Helebrant F., Jurman J., Fries J.: Maintenance of machines from the point of view of modern functional operation. *Ekonomika i Organizacja Przedsiębiorstwa* 2005, nr 7; Konderla J., Biały W., Bobkowski G.: Computer maintenance managing systems (CMMs) in mining machinery and equipment exploitation – entrance strategy. *Mine Planning & Equipment Selection* 2006, Turyn.

² Biały W., Bobkowski G.: Awaryjność górniczych systemów technicznych. Zeszyty Naukowe Politechniki Śląskiej, seria: Organizacja i Zarządzanie, z. 22, Wydawnictwo Politechniki Śląskiej, Gliwice 2004.

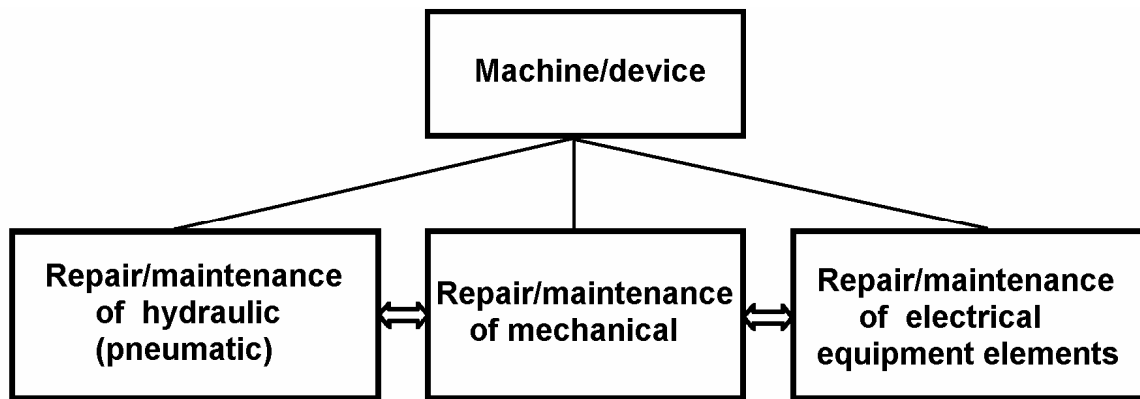


Fig. 1. Service structure flow chart

Rys. 1. Schemat blokowy struktury napraw

Source: Biały W., Bobkowski G.: Awaryjność górniczych systemów technicznych. Zeszyty Naukowe Politechniki Śląskiej, seria: Organizacja i Zarządzanie, z. 22, Wydawnictwo Politechniki Śląskiej. Gliwice 2004.

2. Managing planned repairs of machines/devices

The main purposes of managing the activities connected with preventive maintenance by means of specifying the methodology and responsibility are the following:

- to guarantee that the planned preventive maintenance works will be completed,
- to record the results in the form of reports, archiving.

The procedures describe the stages of preparing and carrying out the operation management plan and end with completing the works and presenting an account for them. The works can be carried out by the departments of coal mines or outsourced companies (fig. 2). The following is a sample description of the activities used:

- instructions for the planned inspections, updated with the data from the previous ones must be available for each machine/device. They are prepared on the basis of the technical documentation provided for the machine/device.
- the operation management services feed inspection cards specifying the frequency and methodology of the inspections into the computer system (CMMs),
- the operation management services divide the works among individual departments (e.g. electrical, mechanical, outsourcing, etc.)
- the works are carried out to meet the needs of the users of the machines/devices and after consultation with the operation management services and/or outside companies,

- the works are carried out by the employees of the coal mine's operation management services or by outsourced companies in accordance with the recommendations specified on the inspection cards,
- the inspection cards are used to prepare the reports from the works,
- when works which were not listed in the inspection schedule must be carried out, the entity responsible for carrying them out requests that further works are performed, which initiates other procedures for repairs,
- if an outside company becomes involved, the operation maintenance services perform a check to ensure the inspection was carried out properly,
- if the data obtained after the works are completed indicate a need to change the frequency and/or the extent of a scheduled inspection, the operation maintenance services update the card,
- the operation maintenance services register the completion of the works and if an outside company was involved they issue a service completion confirmation note.

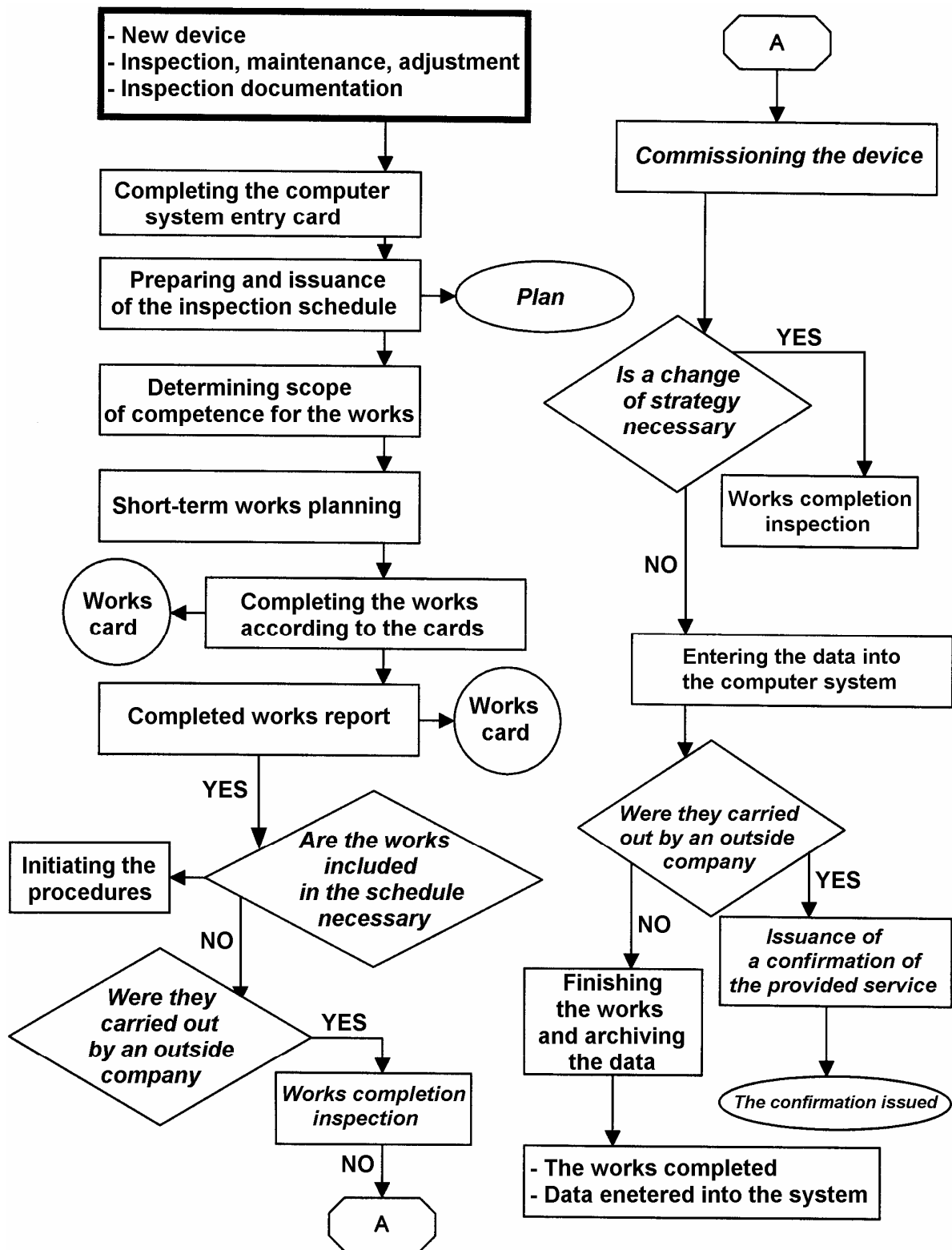


Fig. 2. Machine service management diagram
 Rys. 2. Schemat zarządzania przeglądami maszyn/urządzeń

3. Unscheduled repairs and major repairs of machines/devices

The following are the principles of managing unscheduled repairs/major repairs of machines/devices:

- the completion of the repairs/major repairs is guaranteed,
- the results are recorded.

The procedure describes the sequence of activities necessary to manage repair/major repair works when the 'user' or one of the operation management departments has issued a request for them. The procedure finishes with the completion of the works and the recording of the data and sending them to the archive.

The works can be carried out by own operation management services (fig.3) or outside companies (fig. 4). The following is the description of the works carried out by the operation management services in a coal mine:

- the 'users' of the machines/devices report a need for an unscheduled repair/major repair if there is a failure or breakdown. Also the operation maintenance services can demand the repairs if faults were detected during routine inspections,
- if the works are urgent the time when the works are to be carried out is arranged according to the 'user's' needs, if the works cannot be carried out by the services from the coal mine, outside companies must be contacted,
- the works are carried out by the operation maintenance service workers, who use the relevant operation cards and instructions,
- an operation management service worker hands over the machine/device to the 'user' and sends the completed card to the archive, the completion of the work and its duration is recorded,
- minor works are outsourced by the operation management services,
- the operation management services check whether the works provided by an outside company are complete and effective,
- if a heavy repair/major repair is necessary, a standard purchase process should be used, which is initiated by appropriate procedures,
- the confirmation note stating that the service has been completed is issued by the operation management services after the works have been completed and their effectiveness has been checked.

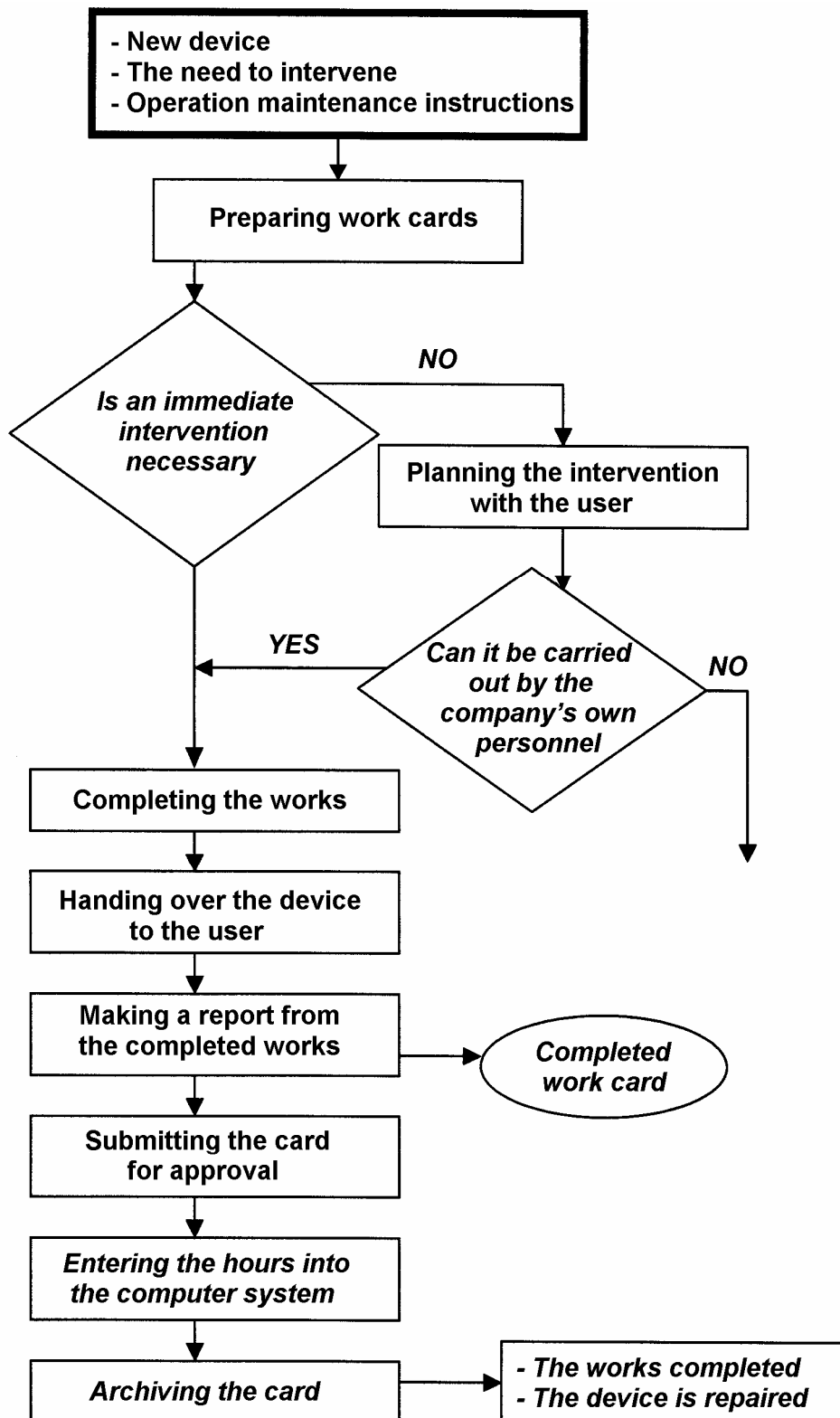


Fig. 3. Traffic maintenance crew operation diagram in case of unexpected maintenance and service of machinery

Rys. 3. Schemat postępowania służb utrzymania ruchu w przypadku nieplanowanych napraw/remontów maszyn/urządzeń

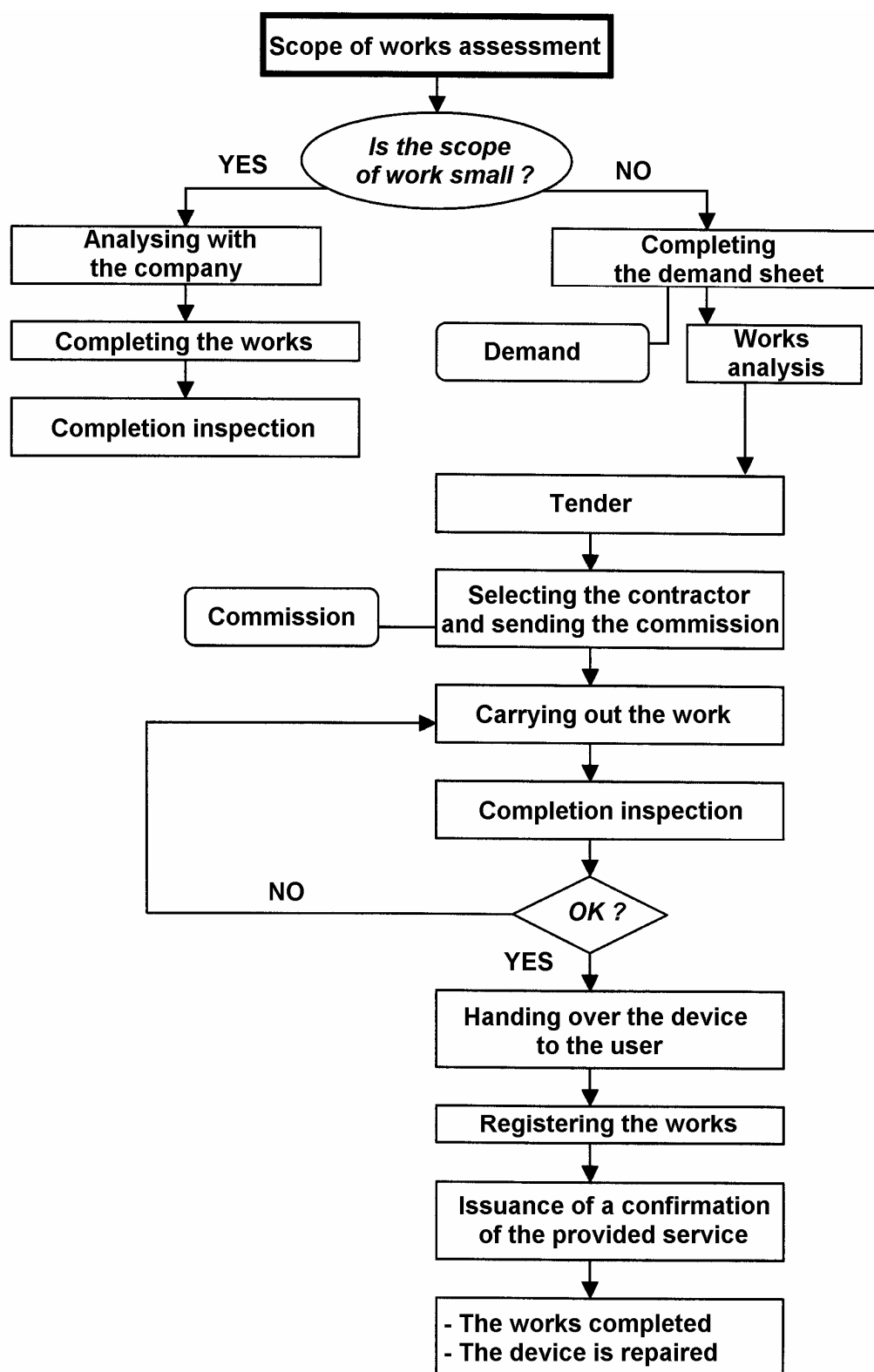


Fig. 4. External contractor operation diagram in case of unexpected maintenance and service of machinery

Rys. 4. Schemat postępowania firm zewnętrznych w przypadku nieplanowanych napraw/remontów maszyn/urządzeń

4. Using CMMs class systems in maintenance management in coal mines

Optimizing maintenance processes and modernizing complex systems, such as power engineering and mechanical systems, need an effective tool to provide a comprehensive support for large projects usually carried out under the conditions of full mining operation.

A tool to improve the functioning of the operation management services in a coal mine can be a solution consisting in the implementation of a CMMs-class system, which will cover a full scope of operation management activities. CMMs-class systems provide support for operation processes such as means and operation system maintenance through technical, organizational and economic activities. These systems signal the need to perform preventive maintenance and repair activities, ensure a timely provision of the desired quantity of operational resources (tools, spare parts, consumables, specialist equipment) for the maintenance and repair activities.

Also, it is possible to pass messages quickly and by the same token to undertake prompt action in emergency situations, which as a result contributes to the following:

- optimizing and minimizing the time necessary for maintenance,
- managing the documentation of the tasks being carried out.

When implementing a CMMs system in a coal mine, apart from making a technical assessment of individual systems, the following measures must be taken:

- the information technology means available in the company such as computer networks, software and databases, computer hardware and operation systems with the technical parameters suitable for CMM systems must be checked,
- the possibility of integrating the new CMM system with the information technology systems already present in the company (e.g. accountancy, pay, personnel, warehouse management systems etc.) must be considered,
- the structure of technical information flow in a coal mine at the level of the mine operation management services and their connections with the superior (and external) structures must be determined.

Implementing CMM systems in a coal mine should begin with a detailed analysis of the interconnections between the already existing technical facilities directly involved in the mining process and a possibility of a their subsequent adaptation to the entire technical structure of the mine.

At the moment the most advanced systems can be used in many branches of the same company often situated in different parts of the world (globally, locally), in several time, language and currency zones etc. Such installations optimize asset management within the whole organization. Regardless of the size of an organization (company) the availability and operation of the income generating assets can be improved. Using management support

systems can reduce the time and cost of maintenance, guarantee access to the necessary parts and at the same time reduce stocks and improve the deliveries and the organization of outside contracts.

IT systems can therefore be used in just one company or in a number of entities, which are for example part of a larger structure such as a group/holding/company. CMM systems can be implemented locally (mining and haulage facilities in a single mine) and globally (managing scattered organizations). This convenient function allows one to centralize or decentralize the place of storing and processing information (data) according to the strategy of the company within one created database.

The way how the CMMs tool can be used by means of carrying out uniform works for all the dependent organizations making up one entity (group/holding/company) is shown in fig. 5.

The system can be used to define any number of organizations and/or companies and to choose a separate management method at the level of the company, organization or branch for organization and economic issues (account systems, base currency, financial reports) and operational data (subcontractors, taxes, works commissions etc.). Such a solution makes the management of spare parts, human resources and equipment which is part of the company's movable property more efficient.

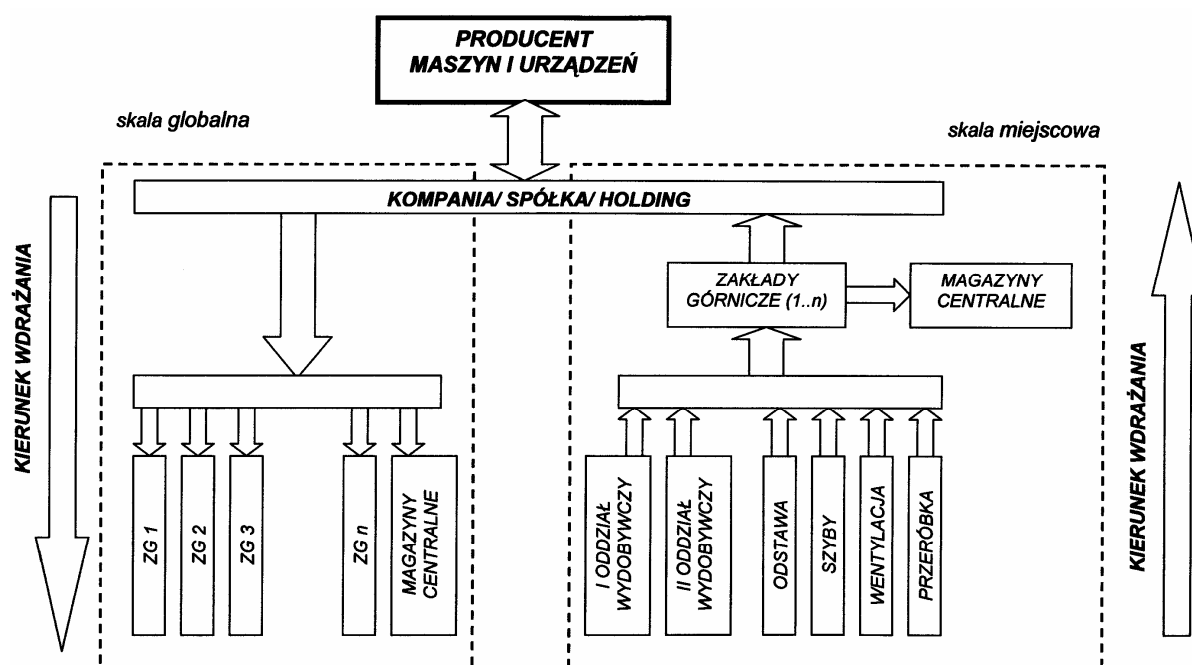


Fig. 5. Global and local strategy of CMMs systems introduction

Rys. 5. Globalna i miejscowa strategia wdrażania systemu CMMs

5. Directions in the development of CMMs-class computer systems

Computer systems supporting the management of machine and device operation and company operation management have changed significantly in recent years (fig. 6). This is the result of the users' growing demands and the development of computer technologies both in terms of the efficiency of the hardware but also in terms of the capabilities of operation systems and new working platforms. Both these factors are inseparable and in some sense complementary. The demands of the users present IT technologies with challenges and at the same time new aims can be achieved as these technologies are being developed. The development of IT technologies creates new needs in the users and makes it possible to satisfy those needs. Functionally, the systems supporting technical facilities operation management have developed from simple Computerized Maintenance Management system programs (CMMs) used to put in order the maintenance management in a manufacturing company to complex systems supporting enterprise asset management (EAM) and systems used for strategic asset management (SAM).³

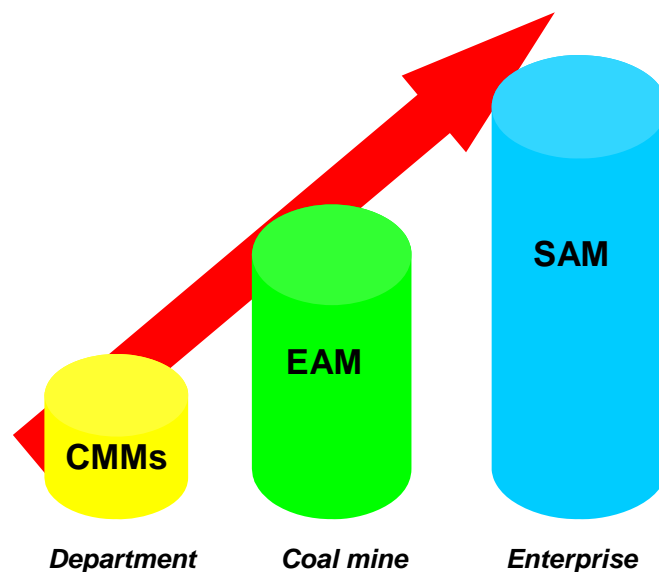


Fig. 6. Evolution of systems supporting machinery utilization management and traffic maintenance

Rys. 6. Rozwój systemów wspomagających zarządzanie eksploatacją maszyn i urządzeń oraz utrzymaniem ruchu

Source: MRO Software Inc, Strategic Asset Management Executive White Paper, 2003

They can be used not only in applications strictly connected with manufacturing. Its functions have been extended to such areas as the following:

- Facility Management,
- IT infrastructure management,
- internal and external transport management,
- supply of parts and materials necessary for maintenance management,
- outsourcing contracts, etc.

At the moment the most advanced systems can be used in many branches of the same company often situated in different parts of the world (multi-site, multi-organization), in several time, language and currency zones etc. The time and cost of maintenance can be reduced by e.g. guaranteeing access to the necessary parts, reducing stocks, improving the deliveries and the organization of outsourcing contracts.

The pool of information available in the system, including historical and current data as well as future plans, helps in the asset management during the entire life cycle. The fact that the key equipment elements and exact information regarding what parts and at what time will be necessary can be determined will make it possible to assess the actual cost of maintaining the assets and to find ways of reducing them. Asset management can even be started before the machine/device appears in the organization and before it is used. Thanks to the creation of a virtual catalog of the company's assets (e.g. MAXIMO Illustrated Parts Catalog) according to the description standards adopted in the whole organization (e.g. StruxureTM and Standard Modifier DictionaryTM) the system allows the employees to move around the structure of the assets complete with detailed drawings/diagrams of its elements and to find a particular site, determine the necessary items in need of repair and to find them in the supply chain. Throughout the entire life cycle of the assets in the organization, modern systems to support operation management facilitate the activities connected with planning and scheduling management.

The development of the systems is closely connected with the rapid developments in IT. This refers among others to communication techniques and data transmission. Having become common, more functional, reliable and safer in terms of data transmission, network systems (the internet, intranet) not only extended the application of management support systems to the entire organizations but they also allowed for connections between organizations to be created, which can be used to carry out a range of activities such as supply of parts and materials, service contracting etc. The 'Automatic delivery' generates significant savings. Based on the analyses of the Boston Consulting Group, AMR Research estimates that among the largest global companies the reduction of delivery cost may reach as much as 60%.⁴

³ MRO Software Inc, Strategic Asset Management Executive White Paper, 2003.

⁴ Ibidem.

The development of mobile computers also has a great impact on EAM systems. Instead of a (very often large) collection of paper documents, an employee receives a device which has access to all the tasks he was given and all the necessary information he/she may need to carry them out. The activities are also reported by means of the same device as the works progress, which provides an ongoing supervision of how much of a given task has been completed (progress supervision). Appropriate devices can be chosen from among a wide variety of portable computers for the purpose of achieving the goals. Data transmission to and from a portable device can be carried out in several ways depending on its functional connection with the main system (a docking cradle, an on line connection via a cordless network, a connection via mobile telephone networks, a dial-up connection, an IRDA connection).

The development of computer systems used to support the operation management of technical facilities could not be independent of the specific requirements on the side of the users. At first, with a limited functional possibilities of the early systems (usually consisting in merely ‘ordering the maintenance management’), they could be adapted to the needs of the users by making minor modifications. As they developed, the systems had to be ‘specialized’.

Versions dedicated for the following started to appear:

- the manufacturing,
- the technical infrastructure,
- transport,
- the IT infrastructure etc.

The systems can be used for a wider range of applications thanks to new modules being ‘added’ to them. The variety of industries, products and requirements made the development of the systems dedicated for the manufacturing sector develop also in various directions. That is why systems for the manufacturing, oil, power engineering (especially nuclear power), pharmaceutical companies, the food industry etc. started to appear. The reason behind all this is to meet the technical and formal requirements characteristic of the particular industry.

6. Summary

The constant development of technology makes machines/devices ever more reliable. There are still situations, however, when machines/devices must be repaired.

A failure of a machine and a long time one has to wait until it is repaired frequently causes great losses for the user. This is particularly true for enterprises which base their activity on using machines, which are very time-consuming or impossible to replace in the

event of a failure due to the absence of a 'spare' machine/device. Such a situation is often encountered with many machines/devices used in coal mines.

A quick repair requires a close co-operation between the user and manufacturer of the machines/devices. Quick access to complete and up-to-date information and the possibility of exchanging them is of essence. In the mining industry the replacement is made more difficult by the fact that there is a geographical distance between the manufacturer and the user of a machine/device.

Another factor influencing efficient repairs is an appropriate management of material and human resources on the side of the manufacturer and the possibility of fulfilling the formal requirements (transfer of the necessary information, circulation of the relevant documents).

Taking the above into consideration, the use of a system which is both a data collection and a communication platform for efficient information and document exchange and one which supports the management of the resources necessary to carry out the repairs proves all the more desirable.

As the management support computer systems develop all the time, the introduction of systems which support strategic asset management also in the case of machine/device manufacturers is inevitable.

Computer systems supporting machine/device operation and company operation management have so far been widely used in many industries. Consequently, it seems inevitable that such systems have to be implemented in coal mines.

The implementation of a CMMs-class system in coal mines should ensure uninterrupted operation of machines/devices, help reduce the costs thanks to a longer operation time and consequently - prolong their life.

The manufacturer of mining machines/devices operates on a large geographical area, in many countries and on different continents. In a situation of a 'difficult market' (which is true for the mining machines/devices market), computer systems have become a significant factor necessary to rationalize activities connected with asset management and bring easily measurable savings.⁵

Bibliography

1. Biały W., Bobkowski G.: Awaryjność górniczych systemów technicznych. Zeszyty Naukowe Politechniki Śląskiej, seria: Organizacja i Zarządzanie, z. 22, Wydawnictwo Politechniki Śląskiej. Gliwice 2004.

⁵ Ibidem.

2. Biały W., Bobkowski G.: Możliwości wykorzystania narzędzi komputerowych w gospodarce remontowej kopalń węgla kamiennego. *Mechanizacja i Automatykacja Górnictwa* 2005, nr 4 (411).
3. Helebrant F., Jurman J., Fries J.: Maintenance of machines from the point of view of modern functional operation. *Ekonomika i Organizacja Przedsiębiorstwa* 2005, nr 7.
4. Konderla J., Biały W., Bobkowski G.: Computer maintenance managing systems (CMMs) in mining machinery and equipment exploitation – entrance strategy. *Mine Planning & Equipment Selection* 2006, Turyn.
5. MRO Software Inc, *Strategic Asset Management Executive White Paper*, 2003.

Reviewers: Prof. dr hab. inż. Józef Bendkowski
Prof. dr. hab. Jerzy Mika