Automated system for definition of life-cycle resources of electromechanical equipment

Y Zhukovskiy and N Koteleva

Mining University, 2, 21st Line, St Petersburg, 199106, Russia

Email: spmi_energo@mail.ru

Abstract. The frequency of maintenance of electromechanical equipment depends on the plant, which uses and runs this equipment. Very often the maintenance frequency is poorly correlated with the actual state of the electromechanical equipment. Furthermore, traditional methods of diagnosis sometimes cannot work without stopping the process (for example, for equipment located in hard to reach places) and so the maintenance costs are increased. This problem can be solved using the indirect methods of diagnosing of the electromechanical equipment. The indirect methods often use the parameters in the real time and seldom use the parameters of traditional diagnostic methods for determination of the resource of electromechanical equipment. This article is dedicated to developing the structure of a special automated control system. This system must use the big flow of the information about the direct and indirect parameters of the equipment state from plants from different areas of industry and factories which produce the electromechanical equipment.

1. Introduction

Technological processes safety is a primary task of plants in the mining industry. The whole electromechanical equipment used in the plant, and especially electromechanical equipment used in hazardous areas, plays the most important role in ensuring process safety. The different methods of diagnosis allow one to increase the reliability of the electromechanical equipment. Using the methods of determination of the resource data of the life cycle of electromechanical equipment, it is possible to predict the development of defects and, thus, prevent accidents at work, directly related to the incorrect operation of the equipment. To ensure the reliable operation of electromechanical equipment in the mining industry enterprises, traditional methods of defect detection are predominantly used. They are based on periodic maintenance and inspection of equipment. Periodic maintenance provides information to the system from time to time. So the diagnostic system has information insufficiency. Despite the high automation and the presence of specific systems, such as ERP and MES systems, the most modern complex system of diagnostic does not solve this problem. The first reason, these systems do not integrate and do not have links with each other. The second reason, these systems do not have special modules which help to create knowledge which parameters influence the defect of equipment. So, for improving the diagnostic methods, we must firstly integrate different systems and, secondly, add special modules. Developing a complex integrated system is necessary for solving this problem.
2. A traditional structure of an automated system for definition of life-cycle resources of electromechanical equipment

The problems of reliable operation of electromechanical equipment and the waste of energy could be solved using the special automated system for definition of life-cycle resources of electromechanical equipment. This system must contain not only usual modules of safety and control, it must contain the special predict module.

The determination of electromechanical equipment’ resources must be realized in three steps. At the first step, the main parameters must be monitored. The main parameters are the parameters that could characterize the basic state of electromechanical equipment. At the second step, the parts of electromechanical equipment must be diagnosed using the different methods. At the third step, the special knowledge must be produced and used. This knowledge shows the influence of different defects on every part of electromechanical equipment and the life-cycle resources of electromechanical equipment. The knowledge helps to make decisions that will influence the life-cycle resources of electromechanical equipment.

A traditional approach that helps to solve this task bases on the automated system for definition of life-cycle resources of electromechanical equipment. This system gives the possibilities for collecting, aggregating and analyzing of data. It has the traditional structure that is shown in figure 1.

![Figure 1. The traditional structure of automated system for definition of life-cycle resources of electromechanical equipment.](image)

According to the figure, a plant has a special diagnostic parameters database. This database contains the information about the state of electromechanical equipment, including the remote equipment. This information is collected, aggregated and analyzed. The data are aggregated inside the
database and could be printed out for the specialist using the special interface in different forms. This report helps do an analysis for the specialists. The tradition automated system has a special function – the indirect parameter calculation. These parameters are calculated according to technological processes data, data of an electromechanical equipment state, diagnostic data and other information that is stored in the database. When the operator has this full information, he can chose the right decision that helps to increase the duration of life-cycle of electromechanical equipment. Often, however, the decision is made on the poor information basis. This information is poor because it is collected according to the instructions of repair. So this dynamic analysis is not carried out. However dynamic analysis has a significant advantage – can detect a fault inherent on the operating mode. In the system, the decisions that affect the continued cycle of electromechanical equipment (repair, replacement parts and the like) are traditionally only fixed, but do not evaluate their influence to the continued functioning of the quality of electromechanical equipment.

Thus, the specialists choose a certain way based on their own knowledge and technological intuition or relying on experience of engineers of technical support of the manufacturer. This method is not always effective and sometimes is of low effectiveness because it uses some experimental averaged data of industrial experience about special facts which can affect the work of the electromechanical equipment. So, the information inside this database usually is not complete and useful. The typical plant cannot solve this problem alone because it uses its own experience but sometimes the reasons of fault of equipment are very different. This problem could be solved using the global information that are collected by different plants which use this equipment and by factories which produce it. So the automated control system must be modified.

3. An advanced structure of the automated system for definition of life-cycle resources of electromechanical equipment

The traditional approach to evaluating the electromechanical equipment life cycle has a number of drawbacks, the main of which is the localization of data on the equipment, the presence of incomplete information about defects and the reasons that influenced their development, often within a single enterprise using this electromechanical equipment and in very rare cases, as part of a partnership the interaction between the company and the manufacturer. This disadvantage can solve the globalization of the electromechanical equipment data. This globalization is possible only with the transition to the new structure of the system (Figure 2).

The functions of the advanced system are realized in a special services form. This services are provided using the Industrial Internet technology. So the database has a two different forms – the private database, which is used in the plant or factory in the private area, and the global database which is used in the public area. Each private database can be aggregated into a single global information system. It is a special intelligent system which must be self-learning and smart. The “smart” means what the system can be adapted under different conditions to aggregate data of different private databases, to produce and to collect the special knowledge during the life-cycle of electromechanical equipment.

This system must have the possibilities to increase the functionality; therefore, the system must have special capabilities:
- it must be integrated, i.e. the ability to be implemented into existing systems,
- it must be self-learning, i.e., the ability to adjust the tuning coefficients during operation;
- it must be adapted, i.e. the ability to maintain their functionality under varying operating conditions;
- it must be self-organized, i.e., preservation of health in terms of commissioning of new loops and variables.

This system can work in different scenarios. To date, the most optimal of which are the following:
- equipment state monitoring;
- a defect detection;
- simulation of the future work of the electromechanical equipment with the identified defect;
- the calculation of the residual life of the equipment;
- development of equipment repair plans.

The first recognition stage - the recognition of the state of equipment defects, without interference in its mode of operation by periodic or continuous observation, measurement - called as the functional diagnosis. In the case of the first stage of monitoring signs of defects, a deeper analysis of the data using the simulation condition of electromechanical equipment under the various load conditions is held.

![Diagram of the automated system for definition of life-cycle resources of electromechanical equipment.](image)

**Figure 2.** An advanced structure of the automated system for definition of life-cycle resources of electromechanical equipment.

The various subsystems must be implemented for realization of a global automation system, including:

- the subsystem information collection;
- the information processing subsystem;
- the subsystem of monitoring of resources consumption;
- the subsystem modeling;
- the diagnostics subsystem;
- the subsystem forecasting residual resource;
- the management and control subsystem.

The created subsystem must cover all workflows from sensors and transmitters, finishing controlled actuators.

The global automated system will improve the accuracy and quality of the assessment of the state and remaining life of the electromechanical equipment, taking into account the quality of the main supply and operating conditions that can set the timing of repairs more accurately and justify the excess period of operation of the unit. In addition, the system will increase the efficiency of the electromechanical equipment fault detection at an early stage in the process of operation, increase...
productivity, increase the accuracy of diagnosis and provide forecasting technical condition of electromechanical equipment.

4. Conclusions
Creating a global advanced diagnostics systems and assessing the residual life of the electromechanical equipment will integrate industry enterprises into a single diagnostic network, will organize the collection and processing of statistical data for more accurate operation of the system and will allow remote users to calculate the state and life-cycle resource of electromechanical equipment according to their actual state. It will lead to lower costs maintenance and repair, and will reveal the electromechanical equipment with high power consumption. The system will combine the expertise of a commercial plant using this electro-mechanical equipment and the experience of industrial enterprises producing electromechanical equipment. This alliance will provide advanced knowledge of the nature of defects, reduce operating costs and improve the energy efficiency of production and operation of electromechanical equipment.

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