

Method of Data storing, collection and aggregation for definition of life-cycle resources of electromechanical equipment

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Abstract. Analysis of technical and technological conditions for the emergence of emergency situations during the operation of electromechanical equipment of enterprises of the mineral and raw materials complex shows that when developing the basis for ensuring safe operation, it is necessary to take into account not only the technical condition, but also the non-stationary operation of the operating conditions of equipment, and the nonstationarity of operational operating parameters of technological processes. Violations of the operation of individual parts of the machine, not detected in time, can lead to severe accidents at work, as well as to unplanned downtime and loss of profits. That is why, the issues of obtaining and processing Big data obtained during the life cycle of electromechanical equipment, for assessing the current state of the electromechanical equipment used, timely diagnostics of emergency and pre-emergency modes of its operation, estimating the residual resource, as well as prediction the technical state on the basis of machine learning are very important. This article is dedicated to developing the special method of data storing, collection and aggregation for definition of life-cycle resources of electromechanical equipment. This method can be used in working with big data and can allow extracting the knowledge from different data types: the plants' historical data and the factory historical data. The data of the plants contains the information about electromechanical equipment operation and the data of the factory contains the information about a production of electromechanical equipment.

1. Introduction

The most common type of electric machines in the world is AC electric motors. The use of asynchronous motors is continuously growing and, according to the experts' predict, their share in the electric drive can reach 85-90% in the next 10-15 years. The costs of maintenance and repair of electromechanical equipment constitute a significant part of the total operating costs of enterprises [1]. The electromechanical equipment used at the enterprise as a whole, and especially the asynchronous motors, used in technologically hazardous areas, play one of the most important roles in providing technological safety, while the experience of electric motors operation indicates a large number of failures.

Operation of the electromechanical equipment in an unsatisfactory technical condition leads to increasing of :



- direct financial losses, associated with unpredictable failure of equipment and caused by this violation of the technological process;
- significant (up to 3-5%) indirect non-productive costs of electricity, caused by increased energy consumption (with the same useful power) [2, 3].

To solve the problems of reliable operation of the electric drive and the elimination of inefficient electricity consumption by equipment in a pre-emergency state, in addition to controlling and protecting the systems, there is a need in the introduction of prediction and estimation of residual resource assessment systems [4].

The introduction of prediction and estimation of the residual resource assessment system is based on the special big data space. The most actual task is organizing this big data space. There are two types of big data space: the private fault diagnostic cloud platform and the global fault diagnostic cloud platform.

2. The private fault diagnostic cloud platform

The private fault diagnostic cloud platform can be organized inside the factory that uses electromechanical equipment and plant that produces one.

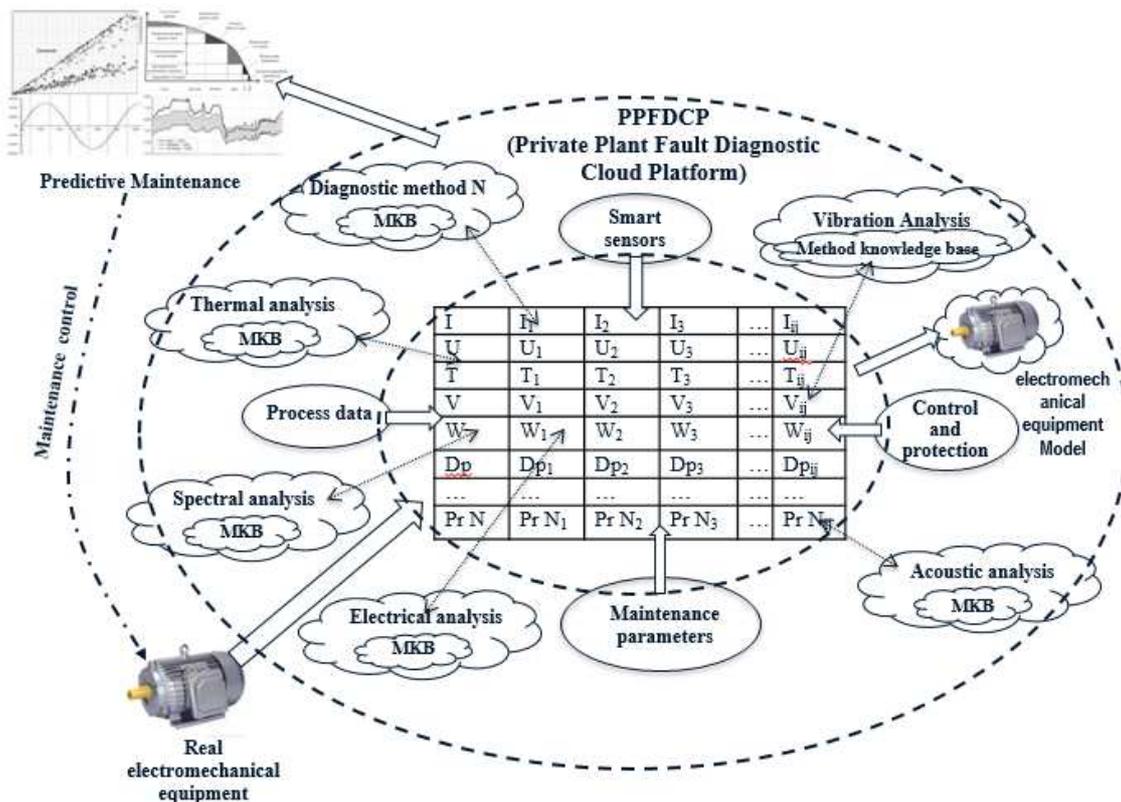


Figure 1. Structure of private fault diagnostic cloud platform

The big data space of Private Plant fault diagnostic cloud platform (figure 1) contains 4 types of data: smart sensor data, process data, maintenance data and control and protection data. All of this data can be produced from real equipment operation (real-time data) and from equipment model (model data). These data can be collected using the different diagnostic methods, such as vibration analysis of individual elements of the unit; analysis of current and voltage spectra; acoustic analysis of vibrations of the operating machine; analysis of magnetic flux in the engine clearance; analysis of secondary electromagnetic fields of the machine; analysis of the temperature of individual elements of the

machine; analysis of iron content in oil; analysis of insulation status; signature testing; analysis of the harmonic composition of the field and etc. Each of this analysis takes the special knowledge about electromechanical equipment. This knowledge is organized with the special cloud services. The different knowledge is collected in the special private knowledge base. The main disadvantage of this knowledge base is information insufficiency because it contains only local data of a plant electromechanical equipment.

Local diagnostic systems, which are founded on the local big data, are effective for large objects with the same type of drives, which have a constant load and speed of rotation. At present, there are no ready-made systems that would be unified and could be used for various industries. Basically, such systems are specialized for specific machines and equipment and are based on vibration analysis. However, for equipment that operates under "severe" conditions with the presence of many parasitic vibrations, and the inability of gaining an access to equipment, the use of such systems is not possible.

At the moment, there is no error-free method of monitoring and diagnostics, since there may be abnormal operating conditions of the electric drive, transients caused by the random nature of the load and the change in the control effect, so the diagnostic methods used must be redundant in terms of physical essence and a set of diagnostic parameters.

A number of studies carried out have allowed the development of a comprehensive diagnostic method that makes it possible to implement predictive maintenance of the electromechanical equipment. However, the traditional approach to the assessment of the life cycle of electromechanical equipment has a number of shortcomings, the main one of which is the localization of data on the operation of equipment, the presence of defects and the causes that have affected their development, most often within the same enterprise using this electromechanical equipment and in very rare cases within the framework of Partnership between the enterprise and the manufacturer. However, most electromechanical equipment is cataloged, it has typical functions in the similar process conditions and production steps. Therefore, some situations and parameters leading to the failure of equipment in most cases have already occurred or is occurring now during operation of electric motors of the same voltage and power class and operating mode. Most diagnostic and motor protection systems detect damage that has already occurred, while information about defects in similar equipment is used only in the form of statistics to determine reliability indicators.

This deficiency can be solved by the globalization of data on the work of the electromechanical equipment. This globalization is possible only with the transition to a new structural scheme of the system for collecting and analyzing information for diagnosis and evaluation of the residual resource. IIoT begins with sensors and sensors of a new generation that have built-in transmitting capabilities. The huge data set (Big Data) that they create turns into information and knowledge through analysis in global intelligent diagnostic systems. The emergence of intelligent analytical tools that allow one to operate the collected data in a mode close to real time opens up new opportunities in the area of developing maintenance systems and controlling the equipment. In this case, each unit of electromechanical equipment is endowed with "intelligence" without the need for an integrated intelligent automation system.

3. Global fault diagnostic cloud platform

The global fault diagnostic cloud platform uses data and knowledge of private fault diagnostic cloud platforms. These platforms contain data of different spaces of plants and factories. The global platform has a lot of functions. Some of them – the function of solving of information insufficiency problem. For example, electromechanical equipment works on the plant 2 (figure 2). It has the private fault diagnostic platform. This platform has some parameters. During the operation, a lack of data was identified.

The global cloud platform helps to solve the problem of information failure as follows:

1. The task of data identification is solved at the level of the private cloud platform.
2. In the event that the data for solving the problem do not sufficiently address the private knowledge base

3. If information in the private knowledge base is not sufficiently addressed in the global knowledge base.
4. The global knowledge base contains all information about similar electromechanical equipment obtained during the operation by different plants and information obtained by the manufacturers of these electromechanical equipment
5. The global knowledge base looks for a private knowledge base that contains information about empty data
6. When the empty data is in the global knowledge base, it passes them to the private knowledge base that requested them.

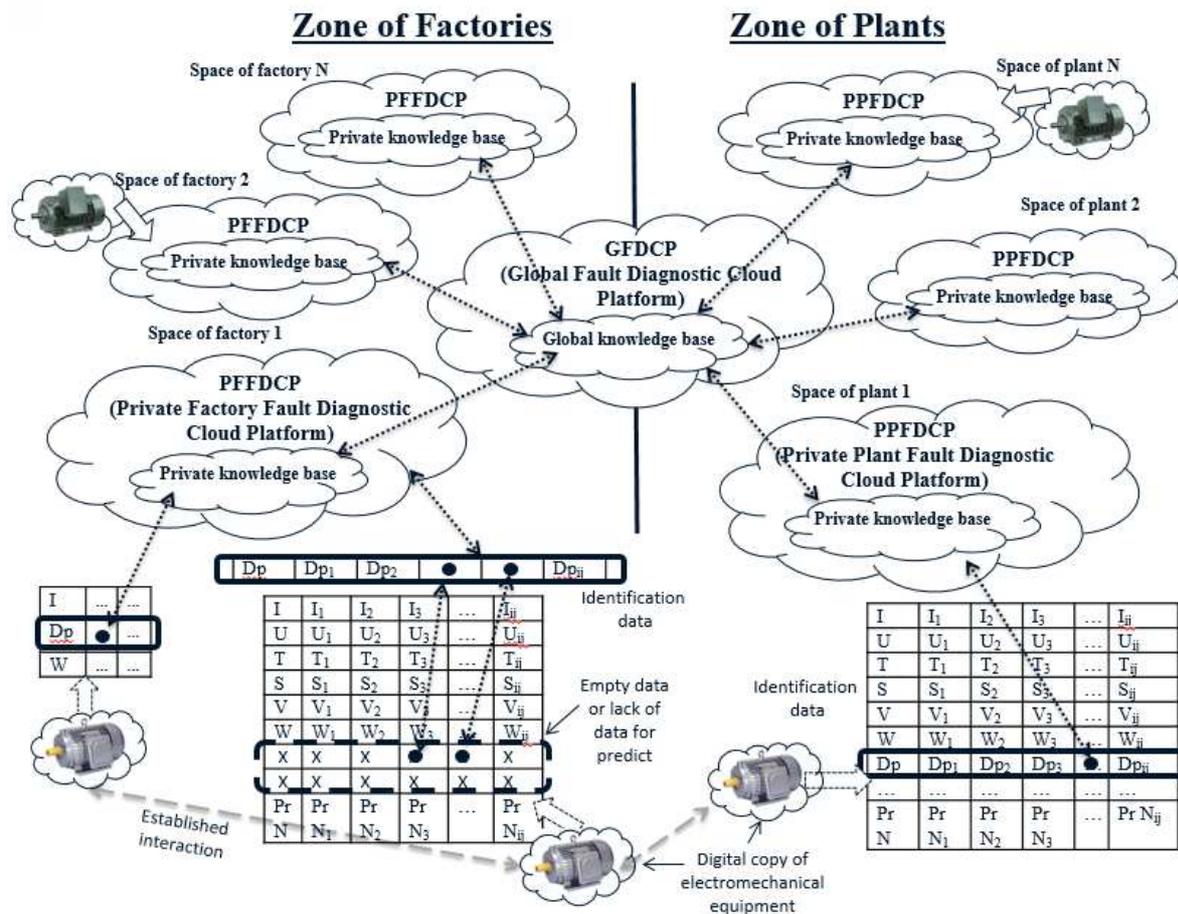


Figure 2. Structure of global fault diagnostic cloud platform

Thus, the private knowledge base receives information from the global knowledge base in the form of a digital copy of the electromechanical equipment by which it can restore the missing data or conduct other necessary analyzes and calculations.

The global fault diagnostic platform connects and links the different devices. The "connectivity" of devices will allow one not only to globalize data, but also to accumulate and use knowledge in the form of special software-as-a service (SaaS) services, which will give a quick and noticeable economic effect. These services provided using IIoT allow one to improve the analysis and the use of operational data, as well as to reveal their value for various services.

The created digital copies of the electromechanical equipment can establish trusted connections for data exchange with the aim of forming a complete diagnostic picture and forecasting the state, while a large amount of historical data collected during the life cycle of the equipment does not disappear as a result of physical disposal of the equipment. A digital copy can stay in the cloud and serve as a source

of missing information for newly introduced equipment that comes in for replacement. The prediction system in the analysis searches for suitable objects with the same parameters and conditions or collects data from different digital copies to form a more advanced diagnostic data field for building forecasts with greater accuracy and confidence interval. In this case, the filling of the diagnostic field must take into account the current state of the engine.

The result of modeling and forecasting on the basis of collected own and retrieved (found) data from the current moment and analysis of large arrays of historical data of previous life cycle periods is the development of information and control actions such as: load restriction in order to extend the service life; full stop for the purpose of recovering the required resource or repairing the damage at an early stage; advance transfer of the job to the reserve equipment in order to prevent the shutdown of the technological process; ordering parts taking into account maturing defects; assessment of the feasibility of withdrawal to repair or maintenance, etc.

4. Conclusions

The combination of protection, diagnostics, residual resource assessment, monitoring, simulation, production management and maintenance and repair technology based on IIoT will reduce maintenance and repair costs, eliminate sudden equipment breaks, increase the flexibility of the equipment lifecycle management system, and provide advanced knowledge of the sources and causes of defects.

The distributed information and analytical complex (software services software-as-a service (SaaS)), integrated into intelligent low-voltage networks, using the technical condition of an AC drive for evaluating and prediction, becomes the key to diagnosing, evaluating and predicting the technical condition of electromechanical equipment for which these expensive systems were unavailable.

The developed system, focused on researching processes, related to the assessment and prediction of the residual life of electromechanical equipment, will reduce the cost of maintenance and repair, eliminate sudden equipment stops and inefficient electricity consumption.

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