Functioning condition monitoring of industrial equipment

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Abstract. The paper analyses the theoretical aspects related to monitoring industrial equipment. Are treated issues that concern the choosing of industrial equipment to be monitored, the parameters to be monitored, monitoring mode (local or remote) and the mode of collection and transmission of data.

1. Introduction

The current national economic situation is characterized by fierce competition between different manufacturers. In this competition the continuous and proper functioning of industrial equipment is an extremely important objective. This can be achieved by purchasing some equipment with a high reliability level and by implementing a performing maintenance system.

The two directions previously mentioned have one major restriction: the purchase price or implementation price. Variation of acquisition costs of equipment and maintenance costs depending on the level of reliability is known and is mentioned in specialty literature [1][2][3].

![Variation of acquisition costs of equipment and maintenance costs depending on the level of reliability](image)

**Figure 1.** Variation of acquisition costs of equipment and maintenance costs depending on the level of reliability [1].
In theory the maintenance is defined as the actions necessary for retaining or restoring a piece of equipment, machine, or system to the specified operable condition to achieve its maximum useful life, when the maintenance actions are performed in logistic conditions defined. For maximum efficiency the maintenance actions and the related logistics support are structured in maintenance systems.

The main scopes of the maintenance systems is to keeping the machine functionality at the required level, maximizing the machine capacity and enhancing the machine live-time at the lowest cost. The maintenance systems are based on the logical organization of the works according to several criteria:

- criterion of the resources used;
- criterion of the use of the means for automatic data processing;
- criterion of the cost reduction for maintenance, repairs and storage;
- criterion of the necessity of eliminating the accidental stoppage by preventing some damages, mistuning, permanent wear, etc.

Each of the maintenance systems have advantages or disadvantages that make them preferred for each industrial enterprise. It is also possible the use of different maintenance systems, simultaneous, in a single enterprise, in order to get the full benefits of different maintenance systems. At this time the Romanian industry use some maintenance systems that can be illustrated as in figure 2.

![Maintenance Systems Diagram](image-url)

**Figure 2. Maintenance systems [4].**

2. Condition monitoring
The functioning condition monitoring of the equipment’s can be defined in many ways. The definition of condition monitoring is according to how it is perceived: as part of a maintenance system or as a standalone system.

In the authors' view the functioning condition monitoring is a part of a maintenance system through which is made a collection of data regarding the operation of equipment, transmission or storage of this data, data processing, preparation of reports followed by maintenance action at time recommended.

This opinion is based on the previous experience and on analysis of maintenance systems. In predictive maintenance system and in total productive maintenance (TPM) the functioning condition monitoring is found as a distinct component part, but also in other maintenance systems are found parts of condition monitoring. An example can be found in all maintenance systems: the measuring...
operating parameters and comparing them with standard values. Measurement is made either before entering the repair (when the equipment is functional) or after completing repairs. Data that is collected must be representative for the state of operation of the equipment and are selected after an analysis of equipment. In figure 3 are presents some of the most monitored parameters of the equipment. The figure is not exhaustive and can be completed depending on the type of equipment.

**Figure 3.** Condition monitoring parameters.

An issue of particular importance is the choice of equipment selected for condition monitoring. Selection must be based on a set of objective criteria. Of these [5]:
- cost of machine down-time
- lost production costs
- cost of replacement of machine
- cost of maintenance and cost of spare
- consequential damages
- cost of functioning condition monitoring system
- cost of safety of work
- cost of environmental impact
Each of these factors has a certain degree of influence in determining prioritization regarding the implementation of functioning condition monitoring system. The degree of influence is specific to each situation.

Even if every situation of implementation of the functioning condition monitoring system of equipment should be treated individually can be developed a general logical diagram.

The logical diagram shown in figure 4 has few distinct parts:

- analysis of equipment
- choice of parameters how will be monitored
- choice of monitoring method
- analysis of data
- drafting of reports
- maintenance actions

Figure 4. Logical diagram for implementation of the functioning condition monitoring system [4].
3. Conclusion

The main idea to start the implementation of functioning condition monitoring is that the maintenance remains one of the very few areas where significant increases to company profits can be archived. The benefits of functioning condition monitoring are:

- possibility to early detection of damages;
- moving of maintenance actions before the moment of failure;
- improves equipment reliability;
- minimizes time spent on maintenance and optimized maintenance intervals (more optimal than manufacturer recommendations);
- minimizes overtime costs by scheduling the activities;
- better prediction of maintenance requirements;
- minimizing possible and often even the elimination of accidental malfunctions and stops of production;
- increasing of production time and thus increase the profits;
- less maintenance workload;
- sometimes increase of the working regime for equipment;
- save the costs of spares and minimizes requirement for emergency spare parts;
- improves worker safety;
- improve quality of work;
- improve the factory design;
- increase the efficiency of company.

Figure 4. Logical diagram for implementation of the functioning condition monitoring system [4].
It could be also mentioned the main drawbacks of functioning condition monitoring:

- high implementation costs;
- the need for a superior training for maintenance staff;
- sometimes, especially for the newest equipment the databases for analyze are expensive;
- uniform wear or fatigue failures is not easily detected with measurements CBM;
- the sensors cannot survive sometimes in the operating environment;
- asset modifications might be required to retrofit the system with sensors;
- the maintenance periods can be unpredictable.

References
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