APLICATION OF THE MAINTENANCE METHODS ACCORDING TO THE CONDITION IN ORGANIZATION MANAGEMENT

Zivoslav Adamovic*
Technical faculty “Mihajlo Pupin”, Zrenjanin, Serbia
adamovic@tfzr.uns.ac.rs

Ljiljana Radovanovic
Technical faculty “Mihajlo Pupin”, Zrenjanin, Serbia
ljiljap@tfzr.uns.ac.rs

Eleonora Desnica
Technical faculty “Mihajlo Pupin”, Zrenjanin, Serbia
desnica@tfzr.uns.ac.rs

Jasmina Pekez
Technical faculty “Mihajlo Pupin”, Zrenjanin, Serbia
jpekez@yahoo.com

ABSTRACT

Condition based maintenance focuses on expensive long-life assets that are subject to condition monitoring. The paper presents a methodology to utilise available information from condition monitoring systems. The maintenance models according to the condition are shown in the paper and those are the following: the maintenance according to the condition with the control of parameters and the maintenance according to the condition with the control of the reliability level. It is the modules of developed models that have been given and the stages of development that have been analysed. The algorithm of the prognosis of the technical condition has been developed.

Key words: Condition based maintenance, Models

INTRODUCTION

Since the late 1950s the use of condition based maintenance has expanded. The shift from a time based maintenance strategy to condition based maintenance (CBM) strategy has proven beneficial in several cases. Increased system complexity, technological development, expensive production facilities, and introduction of new condition assessment tools have contributed to the use of CBM strategies. However, the authors believe that there is still a significant potential in better utilisation of information from condition monitoring and related decision support tools in both long term and short term maintenance planning (Thorstensen, 1999).

THE MAINTENANCE ACCORDING TO THE CONDITION

The maintenance according to the condition is a kind of preventive maintenance whose strategy of making decisions on the maintenance activities depends on the periodical or persistent control of the technical condition of the system within the exploitation process. On the basis of the results of the control, the decisions on the necessary deadline and the amount of the planned maintenance activities are made. Whereas the classical preventive maintenance includes the maintenance activities that are performed after the appointed time, the maintenance according to the condition includes the control of particular technical parameters of the condition and there is an intervention only if the technical condition exceeds the prescribed limits.
The maintenance according to the condition is a diagnostic process which is carried out in the way that, primarily, within particular time intervals, independently of the condition of damage of the constituent parts of the system, the diagnostic control of the technical condition is performed, and, after that, depending on the technical condition, it is the maintenance activities on the constituent parts of the system that are performed or those parts remain within the exploitation process further on.

During each diagnostic control of the technical condition it should be necessarily decided whether the constituent part of the system is to be re-installed, repaired or discarded. Therefore, the constituent parts of the system that can be maintained, should have the wear-out limit ('the usability limit').

The awareness of the allowable wear-out is one of the prerequisites for the quality and economical performance of the maintenance activities as well as the prerequisite for the application of the method of the maintenance according to the condition.

Technical systems in industry provide the possibility of applying a large number of models of the maintenance according to the condition, whereby some necessary conditions must exist. The research has contributed to those models dividing into two groups (1) (Figure 1):

- the maintenance according to the condition with the control of parameters, and
- the maintenance according to the condition with the control of the reliability level.

The maintenance according to the condition with the control of parameters includes a persistent or periodical control and measuring the technical parameters which determine the technical condition of the constituent parts of the system. The decision on the maintenance activities is made when the values of the controlled parameters (e.g. the level of vibrations) reach the ‘usability limit’, i.e. the pre-critical level. The maintenance according to the condition with the control of the reliability level includes collecting, processing and analysing the data about the reliability level of the constituent parts and their elaboration. The decision on the necessary planned maintenance activities is made after the reduced reliability.

THE MAINTENANCE ACCORDING TO THE CONDITION WITH THE CONTROL OF PARAMETERS

Basic Modules

The maintenance according to the condition with the control of parameters has the planning-forestalling character. The periodical performance and the amount of work for the technical diagnostics are determined, whereas the forestalling character is provided by a constant control of the technical condition of the system in order to find the condition leading to a failure ($\varepsilon_1$) and the wear-out limit ($\varepsilon_2 = $...
In order to find out the conditions $\varepsilon_1$ and $\varepsilon_2$, the principle of determining the tolerance for diagnostic parameters (the diapason between the maximum parameter level and the one before the failure occurs) can be used, whereby the system failure occurs at the moment when the parameter of the system condition reaches the bordering level ($\varepsilon_2$).

If the condition parameter reaches the value $\varepsilon_1$, it means that it is necessary to perform some maintenance activity in order to escape the failure of the system (replacement or repair of the constituent part of the system should be performed at the moment of the diagnostic control when $\varepsilon < \varepsilon_1$) whereby the value of the forestalling tolerance ($\Delta \varepsilon = \varepsilon_2 - \varepsilon_1$) is connected with the value of the periodical performance of the diagnostic control ($\Delta T = T_2 - T_1$).

A correct or incorrect technical system can be presented as a dynamic system, whose technical condition is at any moment determined by the values of input, internal and output parameters, i.e. this problem can be solved by the cybernetic principle of 'the black box'.

The performed operations of the technical diagnostics can be divided into three stages: the transformation of the physical phenomena which follow the operation of the examined technical system into a diagnostic signal (electrical value), measuring (registering) certain parameters of the diagnostic signal (e.g. a certain relative value), comparing the values of the measured parameters of the diagnostic signal with the allowable values of the determined technical norms ($\varepsilon_2$). If $\varepsilon < \varepsilon_2$, the technical system can operate properly, but if $\varepsilon > \varepsilon_2$, the system is out of order, so the exploitation process must be either interrupted or further performed under special control. The choice of the diagnostic control parameters of the technical condition and searching for the failure of each part of the system are carried out on the basis of the following:

- studying their function, way and conditions of operation,
- analysing the level of their functioning,
- making logical schemes of cause-related connections of the parameters and factors influencing the operational ability of the technical system,
- analysing the failure etc.

The chosen parameters of the technical condition (vibrations, temperature, pressure etc.) should completely define the condition of the constituent parts of the system, which enables predicting the moment of the deviation of the basic characteristics of the constituent parts and/or the system from the nominal (allowable) values. When choosing the parameters it should be taken into account that their number is to be as small as possible (it is most desirable that there is one, two or three parameters).

Taking into consideration the alteration of the technical condition of the system leading to the parameters exceeding the nominal limits and performing their division in relation to the speed of the alteration of the technical condition (possible criterion for classification), all the technical systems in industry can be classified into those where the alteration of the technical system is performed momentarily (discretely) and the ones where the alteration of the technical condition is performed gradually (monotonously). According to all the above mentioned, it is possible to form a model of maintenance according to the condition with the control of parameters (1) which involves the application of the method for (Figure 2).

![Figure 2: The stages of the development of the maintenance according to the condition with the control of parameters](image-url)
Defining the legitimacy of the technical condition alteration on the basis of the history of the condition alteration, such as in Figure 3.

Defining the diagnostic system of the system condition such as in Figure 4.

Figure 3: Research into the history of the alteration of the technical condition of the system

Figure 4: Modules of technical diagnostics within the process of the maintenance according to the condition

Defining the anticipation system of the system condition (getting ideas about the technical condition in the future or prognostication ('usability reserve'), such as in Figure 5.

After solving the problem of determining the diagnostic regime (defining the anticipation of the condition of the system), i.e. determining optimal periodical diagnostic controls for the constituent parts of the system, with respecting the signalization tolerances for the controlled parameters, there is a new problem of grouping periodical performances of diagnostics and the maintenance activities for the constituent parts of the system within the optimum type of standard diagnostics. The optimum variant of standard diagnostics can be determined according to the criterion of the minimal average annual costs of the maintenance system together with taking into account the costs due to the production failure.
The maintenance according to the condition with the control of the reliability level

The basic approach while defining the maintenance according to the condition with the control of the reliability level amounts to the fact that the constituent parts of the system are used without limiting the resource between repairs with performing the necessary maintenance activities while removing the existent failures, whereas the real reliability level is within the limits of the determined (allowable) norms. If a deviation occurs, the measures for improving the reliability level of certain constituent parts of the system are taken. Accordingly, the reliability level expressed by the reliability indicators has been adopted as the criterion of the technical condition for this maintenance model. In order to solve the given problem, such indicator should possess the maximum information about the technical condition of the system, it must be suitable for performing comparative analyses and it must also be critical to the alterations of the technical exploitation process of the system on the whole. The movement of the failure intensity can best correspond to those demands.

The basic modules of the maintenance according to the condition with the control of the reliability level are shown in Figure 6.

All the information about the reliability of the constituent parts of the system is primarily derived from extensive experiments. There is much less information referring to the results of the research of the operation of the system within the real conditions of exploitation. The failure intensities which are mentioned as the results of the examination of certain constituent parts are often treated as certain ‘nominal’ or ‘basic’ values of this reliability indicator.

On the basis of the estimated failure intensities of the constituent parts of the system it is possible to make the prognosis of the failure intensity of the system. In principle, this can be performed in three different ways:

- estimate of the reliability according to the principle of the similarity of the constituent parts (made with 2-3 alternatives),
- estimate of the reliability applying the method of enumerating the constituent parts (for the parts of identical functions, but different performances) and
- estimate of the reliability applying the analysis of stress (e.g. the alteration of thermal stress with turbines can serve as a real parameter for the reliability estimate).
CONCLUSIONS

Developed models of the maintenance according to the condition can be applied in all industrial branches, as organization management. They are very simple, without special mathematical patterns and do not require complex information systems.

Analytical expressions, which were reached by the application of the linear alteration of the technical condition of the system (other alterations can also be accepted), indicate the influence of the quantiles of normal distribution, mathematical expectation and average square deviation.

REFERENCES


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