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RELIABILITY AND PREDICTIVE MAINTENANCE OF DYNAMIC EQUIPMENT

Ovidiu CHIRIBĂU, Silvia FERENT, Rares PETRUS, Ambrozie PURA, Cornel CIUPAN

Abstract: *This article has as main objective the presentation and familiarization with the reliability and predictive maintenance of dynamic equipment. Maintenance is a wide domain but in this article we focus on listing management methods of maintenance. Main axis of this article is predictive maintenance about which there are presented: the necessity of implementing and main objectives of this method. As a practical predictive maintenance strategy there is presented vibro-diagnosis, this strategy using vibration as a diagnostic tool. In the last part this article presents aspects of implementing a predictive maintenance program and the advantages and disadvantages it offers.*
Key words: *predictive maintenance, reliability.*

1. INTRODUCTION

Problems concerning operation safety of industrial equipment have led to the study of reliability. Nowadays, reliability is a top technique indispensable for engineers. Proper functioning of a machine is limited by the occurrence of a failure.

Good operation and occurrence of failure are contrary situations / events, whose definition is not universal. Depending on the destination of a machine, the state of good functioning is set in the design stage.

The reliability is using scientific knowledge, being a discipline in the engineering domain, that for a certain period of time and well-defined operating conditions, ensuring high performance of a machine functions. This is done by testing and maintaining equipment to acceptable parameters throughout their life. Retention of a machine's performance as long as possible characterizes its reliability.

2. GENERAL ASPECT ON MAINTENANCE

In Figure 1 we can see changes in the typical failure rate "bathtub curve" that characterizes the life of a machine. It is characterized by three typical stages, which are specific to certain defects, as follows:

- infant stage, during which can manifest early failures due to hidden causes deficiencies in manufacturing process control.
- maturity stage, characterized by random failures. During this period, which has the largest share in time, intensity of damage is slightly increasing.
- aging stage, the period of removal from use of the system, during which failures significantly increase due to irreversible damage to the aging process at a structural level (aging, mechanical fatigue) [1,2].

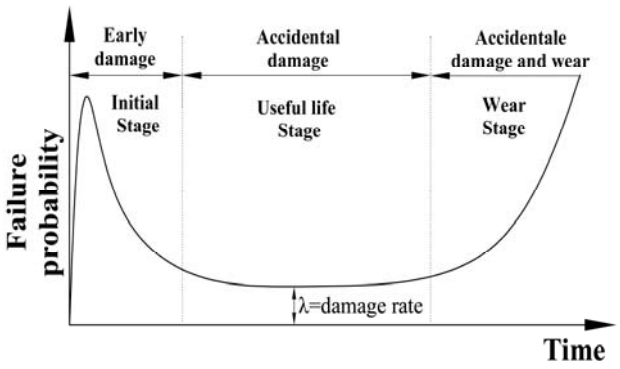

Fig. 1. Experimental characteristic of the falls rate

As it can be seen, regardless the stage of operation a machine is, faults can occur at any time. That is the reason why maintenance service appeared.

According to European Standard 13306 [5], maintenance involves all technical, administrative and managerial measures, performed on a machine during its life cycle, in order to maintain or restore a level at which it can perform the required function. The health and security of maintenance workers are affected in two ways, namely: first, to have reliable equipment you need to plan maintenance interventions and they must be done periodically and, secondly these maintenance interventions must be made in the safest conditions respecting labor protection rules.

Maintenance involves making several operations, which are grouped into four subcategories [6]:

- configuration, training, assembly, installation, disassembly, removal;
- maintenance, repair, installation, adjustment;
- mechanical or manual cleaning of the premises and work equipment;
- monitoring, inspection of manufacturing processes, premises, vehicles, equipment, with or without monitoring equipment.

The most popular methods of maintenance management are:

- Run-to-Failure maintenance (until 1950) is characterized by repair activities only at the occurrence of a fault;
- Preventive maintenance (until 1970) is characterized by planned repairs of equipment;
- Predictive maintenance, this type of maintenance is characterized by periodic or continuous monitoring equipment, both in terms of operational and mechanical intervention ; actions are planned only to reach a level of wear or at the appearance of a defect;
- Pro-active maintenance, this type of maintenance is characterized by strengthening preventive and predictive maintenance technologies. [15-18]

3. ORGANIZATION OF EQUIPMENT'S MAINTENANCE

Throughout the operating cycle of a machine decreases in reliability are recorded, since the marketing stage. According to figure 2, during stages: marketing, design and manufacturing will lose reliability reaching a level of reliability accepted when leaving the factory [1,2]. At this moment T, the machine reliability can vary in two ways depending on the maintenance system implemented, namely:

4AB route. It is characterized by applying proper maintenance system, obtaining low depreciation in reliability of the product followed by rehabilitation of product.

Route 45 678. This is a negative event characterized by large-scale depreciation of the reliability followed by overhaul at large intervals of time. This occurs after applying a system of inadequate maintenance.

The appearance of the predictive maintenance, occurs because:

- the value of industrial equipment has increased;
- the fleet of machines and installations has increased;
- losses in case of damage have increased;
- repair costs have increased.

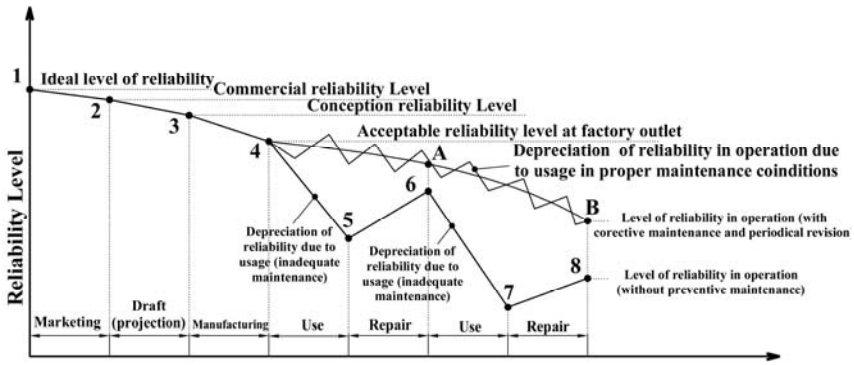

Fig. 2. Organization of equipment's maintenance

The main objectives of predictive maintenance are:

- maintaining equipment in a state of functioning;
- crash avoidance;
- modernization of equipment, while they're being repaired;
- limiting repair costs.

Predictive maintenance is based on active control data at given intervals of time of manifestation ways of equipment functioning in the exploitation process or of working parameters. This includes:

- Vibration measurement;
- Temperature measurement;
- Pressure and workload control;
- Measurement of wear and disturbance component subassemblies;
- The degree of corrosion and erosion;
- Chemical analysis (oil);
- Ultrasounds.

4. DYNCAMIC EQUIPMENT VIBRODIAGNOSIS

The response of a system at the excitation applied to it in a flexible system can be regarded as vibratory motion of a point (Fig. 3). [4]

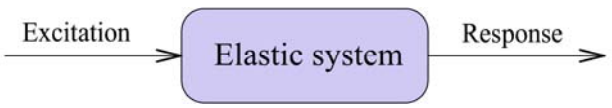

Fig. 3. Vibratory motion of a point

Vibrodiagnosis state of operation of the dynamic equipment is based on energy transfer in the different components, located on the route of the transfer, can be excited mechanically, and thus falls under the vibration. Vibrations have a negative effect primarily on dimensional accuracy and shape generated surface, quality of processed surface. Productivity of dynamic machines is limited by the vibration level.

Once one knows the causes of occurrence and of existence of vibrations one is able to establish the necessary measures to reduce or eliminate them, resulting in performance improvements of equipment quality.

For the correct interpretation of the vibrations one must know the most important parameters of oscillatory movement, which are: pulse (dependent on initial conditions), amplitude (size parameter characterizing vibration size) and the effective speed / acceleration (parameter showing the vibration energy, the intensity of elastic waves, which slightly changes with movement frequency). These ratings give us information on the proper functioning of a system such as: speed vibration, informs us about the energy of vibration produced by the environment that vibrates, vibration acceleration informs us about the intensity of application forces, which works because of vibration, and vibration amplitude gives information if there is movement between parts.

In specialized international literature vibrodiagnosis has been used for a long time in detection and identification conditions of dynamic equipment. Predictive Maintenance is possible by recognizing the smaller trends over time, of vibration, compared with a reference to assess the state of operation of the machine. In contrast to corrective maintenance where rapid response is the first requirement, predictive monitoring is not limited in time and uses a variety of complex features. Maintenance focuses mainly on identifying a procedure for

obtaining their own frequencies, especially for bearings and gears. [10-19]

Vibration structure studied to be measured and analyzed must be captured. Wave energy capture is achieved using a magnetic vibration transducer that is placed either directly on the track, or within small distance.

Captured signal is converted into electrical signal and is processed to transform its characteristics and obtaining the desired size. According to Figure 4, this is done with a device which performs signal processing integration, amplification, increase the square and square root, analog-digital conversion, etc. Further signal processing will be analyzed in time domain, frequency and amplitude domain.

Finally, measurement results can be viewed and further processed on a computer using special software.

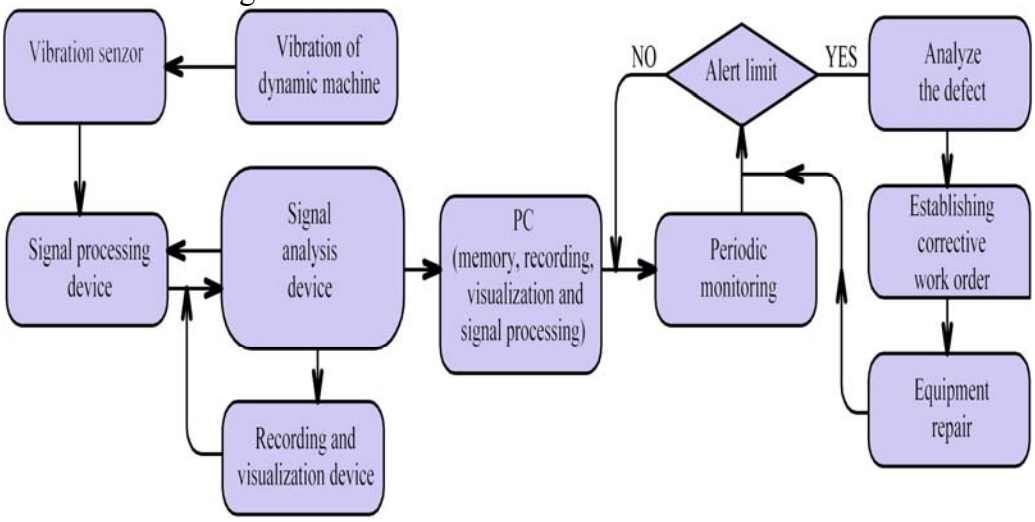

Fig. 4. Basic layout of a system for vibration measurements and analysis

5. IMPLEMENTING A PREDICTIVE MAINTENANCE PROGRAM

Predictive maintenance is a data-driven process based on measurements, it is about collecting and analyzing data to determine what corrective procedures should be made. The key is to make sure that the team accurately analyzes the predictive maintenance data.

Studies have shown that 30% of predictive maintenance tasks can be replaced with a predictive maintenance suitable program.

The benefits of predictive maintenance:

- Lower maintenance costs by 50%;
- Unexpected failures reduced by 55%;
- Repairs and overhaul shall be reduced by 60%;
- Spare parts inventory is reduced by 30%.

In terms of major changes occurring in recent years worldwide and national application of modern methods of maintenance and repair of equipment has become an objective necessity.

Most organizations want to move Europe towards a predictive maintenance program that includes sets of experimental measurements made by means of permanently installed sensors and periodic measurements made with portable and ultra portable instruments. Predictive Maintenance can be done online from sensors installed at regular intervals with a data collector or a combination of the two variants [7].

A basic predictive monitoring program is obtained by comparing the general amplitudes of vibration recorded at regular intervals and using specialized equipment. This monitoring program must be designed to accurately recognize the small changes and use to the simplest and least expensive methods for identifying the car with engine problems from the rest with a good dynamic behavior.

Experienced organizations argue that a regular predictive monitoring program implemented will eliminate accidental shutdown and reduce the total number of machines operating in unsuitable conditions (equipment problems will

be a percentage of the total in the 6-8% available). [8 -10]
Advantages:
- Measurements guarantee the accuracy of machine operation;
- Stops are shorter than the preventive and rare;
- Maintenance is done only when necessary;
- small stocks of spare parts;
- Increases the duration of use of spare parts;
- Requires less maintenance personnel;
- Low costs.
Disadvantages:
- Requires expensive equipment;
- Requires highly qualified personnel for measurement and implementing results.

6. CONCLUSION

As you can see in this article a dynamic machine in operation, no matter at what stage it is burn, life or aging, no matter how high defects rate is it is never null. Therefore implementing a management maintenance methods is absolutely necessary both in terms of the cost of restoring the function and as well as in plummeting its reliability.
In terms of short term efficiency, the best maintenance management method is predictive maintenance. For this category, of predictive maintenance, for the benefits it offers the best practical method is vibro-diagnosis, which is one of the most implemented methods for dynamic equipment.

Vibro-diagnosis implementation costs are quickly recovered by shortage of spare parts, workforce and especially by reducing or avoiding the residence time of production.

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Fiabilitatea si mentenanta predictiva a utilajelor dinamice

***Rezumat**: Articolul are drept principal obiectiv prezentarea si familiarizarea cu fiabilitatea si mentenanta predictiva a utilajelor dinamice. Mentenanta este un domeniu larg dar in acest articol ne concentram pe enumerarea metodele manageriale de mentenanta. Axul principal al acestui articol este mentenanta predictiva despre care sunt prezentate: necesitatea implementarii si principalele obiective ale acestei metode. Ca si strategie practica a mentenantei predictive este prezentata vibrodiagnoza, aceasta strategie folosind vibratia ca si instrument de diagnoza. In ultima parte a acestui articol sunt prezentate aspecte privind implementarea unui program de mentenanta predictiv, precum si avantajele si dezavantajele pe care acesta le ofera.*

Ovidiu CHIRIBĂU, PhD Student, Technical University of Cluj-Napoca, The Faculty of Machine Building, Department of Design Engineering and Robotics, ovidiu_chiribau@yahoo.com, Muncii Boulevard, no 103-105.
Silvia FERENT, PhD Student, Technical University of Cluj-Napoca, The Faculty of Machine Building, Department of Design Engineering and Robotics, silvia2shine@yahoo.com, Muncii Boulevard, no 103-105.
Rares PETRUS, PhD Student, Technical University of Cluj-Napoca, The Faculty of Machine Building, Department of Design Engineering and Robotics, Rares.Petrus@muri.utcluj.ro, Muncii Boulevard, no 103-105.
Ambrozie PURA, PhD Student, Technical University of Cluj-Napoca, The Faculty of Machine Building, Department of Design Engineering and Robotics, purabobi@yahoo.com, Muncii Boulevard, no 103-105.
Cornel CIUPAN, Prof. Dr. Ing., Technical University of Cluj-Napoca, The Faculty of Machine Building, Department of Design Engineering and Robotics, Cornel.Ciupan@muri.utcluj.ro, Muncii Boulevard, no 103-105.