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AWARENESS OF THE IMPORTANCE OF APPROACHING PRODUCTION EQUIPMENT MAINTENANCE IN A STRUCTURED WAY

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Abstract: Use of industrial equipment at high performance and productivity parameters leads to ensuring their productivity and the precision generating the quality of the products manufactured. In this sense, an important role at the organizational level is represented by the activity of maintenance, as a support process that ensures the smooth running of the manufacturing process, respectively manufacturing products. The article presents some aspects regarding the structured approach to the maintenance of production equipment with an emphasis on proactive maintenance and its advantages.
Keywords: maintenance, processes, costs, products

1. INTRODUCTION

In the current context, of the existence of the trend of globalization and the expansion of the competitive market, an important role is represented by the expansion of concerns for the implementation of quality management and the availability of industrial products. In this case, the quality of production activities should be achieved through the existence of high precision and productivity work equipment (Dahlgaard et al., 2005). Production activities must be carried out continuously, a situation that requires the existence of some industrial equipment, which provides continuous operation of the activity, and in case of failure, downtime as small as possible.

Maintenance is not only necessary to ensure reliability of technical equipment or productivity of the company, but regular maintenance has an important role in providing safer and healthier working conditions (Akinradewo et al., 2023).

According to the european standard EN 13306, maintenance can be defined as "(the) combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to".

The economic impact of improper designed maintenance processes is related to costs, downtime, breakdowns, defects, additional inventory, etc., which affect product quality and the company's performance (Ben-Daya et al., 2000; Boriss, 2006).

Maintenance is critical to ensure productivity, to produce products of high quality and to maintain a company's competitiveness. But it also has an impact on occupational safety and health (Bush, 2008). Regular maintenance has an important role in eliminating workplace hazards and providing safer and healthier working conditions. Lack of maintenance or inadequate maintenance can cause serious and deadly accidents or health problems affecting not only workers but also the general public. But maintenance itself is a high-risk activity and it has to be performed in a safe way, with appropriate protection of maintenance workers and other people present in the workplace (Achermann, 2009; Gulati and Smith, 2008).

Being an important component of the production process, the maintenance activity must be carried out at a high quality level, because otherwise there is the possibility of a decrease in productivity in manufacturing and inappropriate economic and financial effects. Considering the new requirements regarding quality, namely the European directives on the safety of machines and equipment, it is considered important to address the problems of their availability (reliability and maintainability) that can solve the multiple issues that arise in production. The article presents some aspects regarding the structured approach to the maintenance of production equipment with an emphasis on proactive maintenance and its advantages.

2. MATERIALS AND METHODS

The stages of existence of industrial products include the following aspects: conception, design-manufacturing, operation and service, as shown in figure 1.

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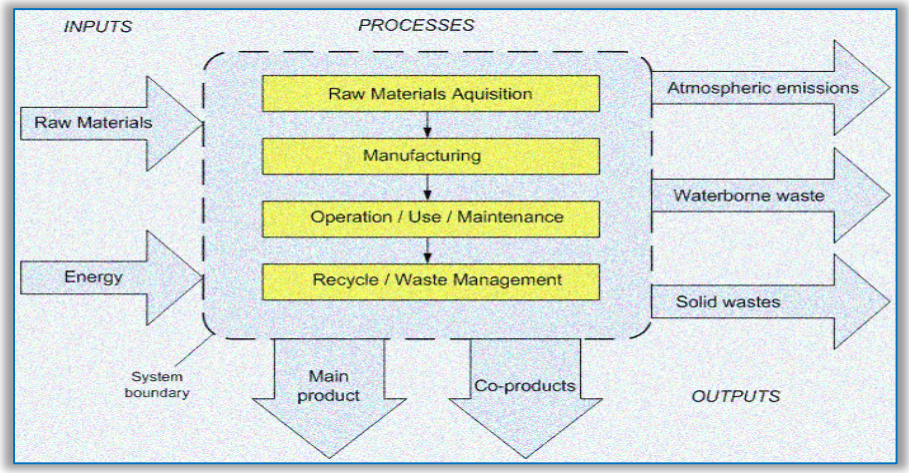

Figure 1 - Main stages and typical inflows and outflows considered in lifecycle assessment

As you can see in the diagram above, any product or technology would require input of some raw materials and energy at all stages: from acquisition to manufacturing, operation, and finally disposal. According to the ISO 14040:2002 all of the mentioned lifecycle stages may produce atmospheric emissions, waterborne and solid wastes, simply because the efficiency of material use and energy conversion is always below 100% - there are losses and by-products, which sometimes can be highly undesirable.

With the appearance of the ISO 31000 series standards (risk management) and techniques and tools in risk management (ISO 31010), respectively quality management systems SR EN ISO 9001:2015 and environmental management systems SR EN ISO 14001 :2015, the global approach to the management of maintenance activities with impact on quality and the environment appears appropriate;

According to the SR EN ISO 9000:2015 standard, the requirement represents: need or expectation which is declared, generally implicit or mandatory (point 3.6.4.). The concept of quality, having a complex character, requires the consideration of a large number of properties or attributes. For the quantitative assessment of quality, it is required, in first, identifying all the characteristics of a product.

Maintenance involves the choice of means of prevention, correction or renovation with the aim of monitoring the wear of the equipment in order to reduce costs, a situation in which maintenance can be considered to mean "surveillance" of the equipment (Băjescu, 2003 and Kelly, 2006). The justification from a technical and economic point of view takes into account the following aspects: - production machines and equipment begin to present an increasingly high degree of automation, being characterized by the compaction of subassemblies and the increase in the complexity of components, a fact that leads to an increase in the complexity of equipment and specialized personnel for these activities; - the equipment has reduced amortization periods and increasing acquisition costs; - the occurrence of stoppages due to the operation of equipment leads to an increase in production costs and repair times, with implications in increasing the price of products.

From a qualitative point of view, maintainability represents the ability of a product to, under conditions of use, be maintained or restored, in operation in the condition to fulfill its specified function in the shortest possible time, using prescribed procedures and techniques (Horenbee et al., 2010; Manzini et al., 2009).

It is appreciated that maintainability is characterized by:

— times for repairs, revisions and downtime for maintenance actions;
— the size of the resources and the level of competence of the personnel working within the actions;
— the quality and volume of spare parts in the safety stock;
— the quality of the operational procedures necessary for the maintenance activity
— management of maintenance activities, etc.

Within the maintenance activity which is considered as a process of restoring an equipment after a failure state (Hohan, 1982) it can be considered as a renewal process defined by a function (t) as the average number of renewals per time unit:

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$$\delta_{(t)} = \frac{d\varphi(t)}{dt} \quad (1)$$

Considering the definition of maintainability as a link between the probabilistic and the functional aspect, it is expressed as follows:

$$M(t_r) = Prob(t_r \leq T_r) \quad (2)$$

where: t_r represents the recovery time (of repair or restoration),
T_r - the maximum limit imposed on the duration of restoration,
M(t_r) - maintainability function.

Corresponding to the MTBF mean operating time without failure, in the case of maintainability the MTR mean repair times are determined.

In the case of a forecast (when designing), either: n – the number of components of the same type; λ – their failure rate; $n_i\lambda_i$ – the hourly average number of defects for the group of elements n_i of the equipment; t_1'- the estimated average time for removing the failure of a component in the group n_i .

Then, the predictive value of MTR is:

$$MTR = \frac{n_1\lambda_1 t'_1 + n_2\lambda_2 t'_{12} + \cdots + n_k\lambda_k t'_k}{n_1\lambda_1 + n_2\lambda_2 + \cdots + n_k\lambda_k} = \frac{\sum_{i=1}^{k}(n\lambda t')_i}{\sum_{i=1}^{k}(n\lambda)_i} \quad (3)$$

If the exponential distribution of operating times and recovery times is considered, the indicator called the availability coefficient is used for evaluation:

$$K_D = \frac{MTBF}{MTBF+MTB} = \frac{\mu}{\lambda+\mu} \quad (4)$$

From the point of view of the economic aspect, the higher the reliability of an equipment, for given technological conditions, the higher its investment cost C_I; however, maintenance costs C_M are lower, given that breakdowns are rare and of low intensity. Conversely, less reliable and cheaper equipment entails higher maintenance costs, thus resulting in the diagram in Figure 1, where the resulting curve C_D = C_I + C_M represents the cost of owning the equipment in availability (Gulati, 2008; Jardine and Tsang, 2005). The use of this chart is made according to the objectives pursued and the requirements imposed on a certain equipment. Typically, the solution C_D = minimum is adopted, to which the reliability Rm corresponds.

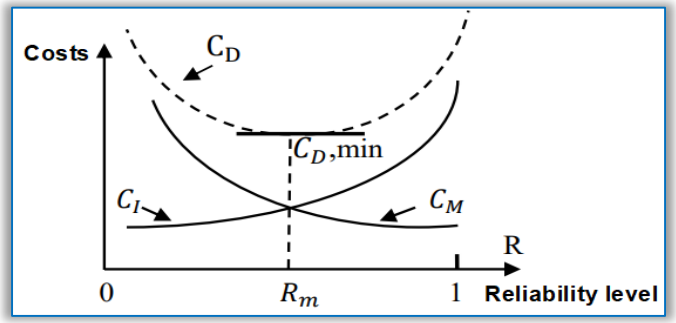

Figure 1 - Diagram of reliability and maintainability costs

Proactive maintenance is a method based on the combined analysis of the traceability of the data related to the behavior of the equipment in operation, which includes the defects that have appeared and the causes of their appearance, the specific measurement of predictive maintenance (vibrations, noises, etc.) and the obtaining of information specific to preventive-planned maintenance, which require the mandatory use of high-performance software products for the management of large databases (Lawrence, 2004).

This type of maintenance can lead to maximizing the availability of production equipment (reliability and maintenance) while minimizing overall maintenance costs. It should be noted that the application of this type of maintenance with maximum efficiency can be carried out if the defects and the causes of their appearance are analyzed immediately (Shang et al., 2023).

This type of maintenance is performed before a breakdown occurs and aims to prevent any breakdown (breakdown). The prevention of damage can be ensured by the competent development of the maintenance program, monitoring the operating parameters of the equipment, ensuring the stock of spare parts, operative human resources, etc.

Proactive maintenance is considered modern and forward-looking and includes activities related to: periodic verification of equipment operation, replacement of elements at the end of the operating period, regular inspections to verify the condition of equipment components, periodic replenishment of consumables. Considering the diversity of the types of benchmarks in the composition of industrial equipment, methods and means of measurement and monitoring intended for the diagnosis of different systems are currently used (Krit and Rebai, 2010).

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3. RESULTS

Maintenance involves the choice of means of prevention, correction or renovation with the aim of monitoring the wear of the equipment in order to reduce costs, a situation in which maintenance can be considered to mean "surveillance" of the equipment. The justification from a technical and economic point of view takes into account the following aspects:

- production machines and equipment begin to present an increasingly high degree of automation, being characterized by the compaction of subassemblies and the increase in the complexity of components, a fact that leads to an increase in the complexity of equipment and specialized personnel for these activities;
- the equipment has reduced amortization periods and increasing acquisition costs;
- the occurrence of stoppages due to the operation of equipment leads to an increase in production costs and repair times, with implications in increasing the price of products

The fourth generation of industrial activity enabled by smart systems and Internet-based solutions is known as Industry 4.0. Two most important characteristic features of Industry 4.0 are computerization using cyber-physical systems and the concept of “Internet of Things” adopted to produce intelligent factories. As more and more devices are instrumented, interconnected and automated to meet this vision, the strategic thinking of modern-day industry has been focused on deployment of maintenance technologies to ensure failure-free operation and delivery of services as planned. Maintenance is one of the application areas, referred to as Maintenance 4.0, in the form of self-learning and smart system that predicts failure, makes diagnosis and triggers maintenance (Lundgren et al., 2023; Shaheen and Németh, 2022).

In the era of collaborative machine community and big data environment, the new trends in manufacturing technology are based on the capability of instrumentation, interconnection and intelligence together with the associated maintenance challenges.

4. CONCLUSIONS

Under these conditions, the role and importance of industrial equipment maintenance activities increases, determined by the following factors:

- improvement through constructive and functional modernization, with the aim increasing the value of equipment;
- increasing complexity by improving the degree of automation a to them; the existence of economic and financial losses as a result of damage or parking of technological equipment for repairs;
- the continuous increase in maintenance expenses;
- it is noted that with the increase in maintenance activities also occurs increasing the degree of involvement of specialized personnel in specific activities

Use of industrial equipment at high performance and productivity parameters leads to ensuring their productivity and the precision generating the quality of the products manufactured. In this sense, an important role at the organizational level is represented by the activity of maintenance, as a support process that ensures the smooth running of the manufacturing process, respectively manufacturing products.

Ensuring the good functioning of the equipment can be achieved by applying some maintenance strategies and appropriate methods, based on the permanent monitoring of their operation. As a result, the planning of maintenance activities must be carried out in following the monitoring and permanent diagnosis of the operation of the equipment, and the application in rational way of specific maintenance methods.

At the same time, the current trend of management implementation and development is noted maintenance, by using modern maintenance methods (TPM, AMDEC, maintenance preventive-proactive, etc.), leading to the reduction of the risk of equipment falls, in conditions of compliance with risk management and compliance requirements quality and environmental standards.

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