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PREDICTION OF WEAR PROCESSES VERSUS QUALITY OF MAINTENANCE

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ABSTRACT
Maintenance in a production company is a key issue however it is usually classified as an auxiliary process for the production. Meanwhile, the process can have a huge effect on the amount and cost of production, quality of the final product, safety of people and the environment. Quality of maintenance depends on many factors – technical state of machines, production plans, implemented strategy, competency of personnel etc. Fundamental meanings can have however possibility to predict course of machines and equipment degradation processes with use of models of different kinds of wear, for instance abrasive or fatigue.

Keywords: quality, maintenance, wear prediction

1. INTRODUCTION

Machine maintenance in a production company is a key issue; however, in a process approach it is usually classified as an auxiliary process for the production [1]. Meanwhile, the process can have a fundamental effect on the amount and cost of production, quality of the final product, safety of people and the environment. Quality of maintenance depends on many factors – technical state of machines, production plans, implemented strategy, competency of personnel etc.

In addition, it is a process which results can be considered in the values of a measurable effort and is relatively easy to manage. All this makes the businesses that apply so-called good engineering practices, maintain machinery is not only an expense to be avoided but also an active action which might constitute an effective contribution to the development of the company.

2. QUALITY OF MAINTENANCE

Plato defined quality of an item as a level of excellence it achieves. On the other hand, ISO 9000 standard defines quality as a level of meeting requirements by a set of inherent characteristics. The important aspect of the last definition is referring the idea of quality with requirements – of customers (internal and external), of users and other interested parties.

In case of trial to define in such concept "quality of maintenance", maintenance and production departments are parties in such a system (requirements - meeting the requirements). It should be noted that Production Departments place the requirements and Maintenance Departments are to meet these requirements. Production Department agreeing to "negotiated" with the Department of Maintenance various indicators of availability of machinery and equipment sets a satisfactory level of quality of maintenance and requires the fulfilment of contract terms. Thus defining quality as a level of meeting the requirements, quality of maintenance can be seen as level of meeting requirements determined by Production Department by Maintenance Department [2].

The effectiveness of any actions, including machine maintenance, will be limited without a precise goal and measures used to monitor the degree in which the goals have been achieved (quality of maintenance). In general, two principles of rational management are correct: the principle of the maximum effect, where the degree of the goal achievement with given resources should be maximized, and the principle of minimum resources, where for an assumed degree of the goal achievement, the resources are minimized. These principles clearly indicate that it is not possible to achieve increasing values of readiness or reliability indexes with simultaneous reduction of sums spent on machine maintenance, inspections, repairs, etc. This truth is frequently missed, which is shown in the so-called conflict of operation managers. The conflict stems from the fact that technical objects participate in two different activities: in their use, oriented towards the product, and their operation, oriented towards the object itself and its value. Therefore, the use of a machine is directly linked to performing a production task, while operation is regarded as an auxiliary process; this is often expressed as "I use the machine (i.e. I produce) while you repair it (you generate costs)". An analysis of Fig. 1 leads to the conclusion that operation decisions should be based on cost calculation which includes the cost of machine operation and the cost of production loss being the result of machine stoppages.

3. EXCELENCE MODEL OF MAINTENANCE

Quality of maintenance depends on many factors – internal, which are connected with Maintenance Departments (for instance competency of personnel etc) and external, not directly connected (like technical state of maintained machines or production plans). On figure 2 proposition of model of maintenance activities excellence is presented. The model assumes, that quality of maintenance - understanding as meeting agreed and reasonable Production Departments requirements - depends on such factors as effectiveness (punctuality, quality) but also efficiency of maintenance activities, compliance with legal and specific, technical requirements including Health&Safety and Environmental issues, compliance with competence requirements like education, experience, skills, trainings, responsibilities and authorities of maintenance personnel and last but not least, compliance with social requirements like working hours, overtimes, remuneration, etc [3, 4].

The first group of success factors (efficiency and effectiveness) depends not only on adopted strategies to use machines but also on the methods and diagnostic tools. It must be remembered, that diagnostic in the full approach is characterized, in addition to assessing the current condition, two other tasks - the genesis (identifying causes of a given set of things) and prediction (the determination of time horizons for future technical changes). From the standpoint of rational decision-making concerning production planning, maintenance and repairs, forecasting technical condition is by far the greatest importance. Known and most widely used in the practice of forecasting methods are based on models of the trend condition - the symptom (linear, linear - quadratic, exponential, etc.) and mathematical models. Often, these models are probabilistic and are based on statistical data collected over the years of operation.

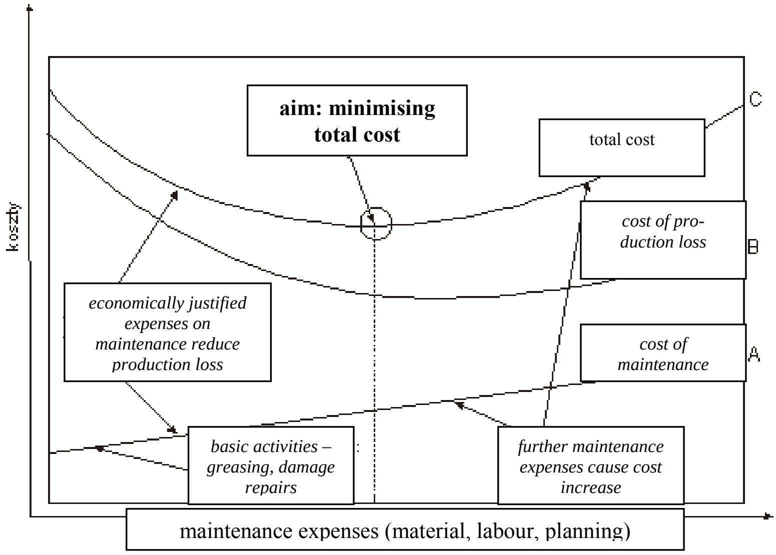

Figure 1. The relationship between the cost of machine maintenance, production loss and total costs.

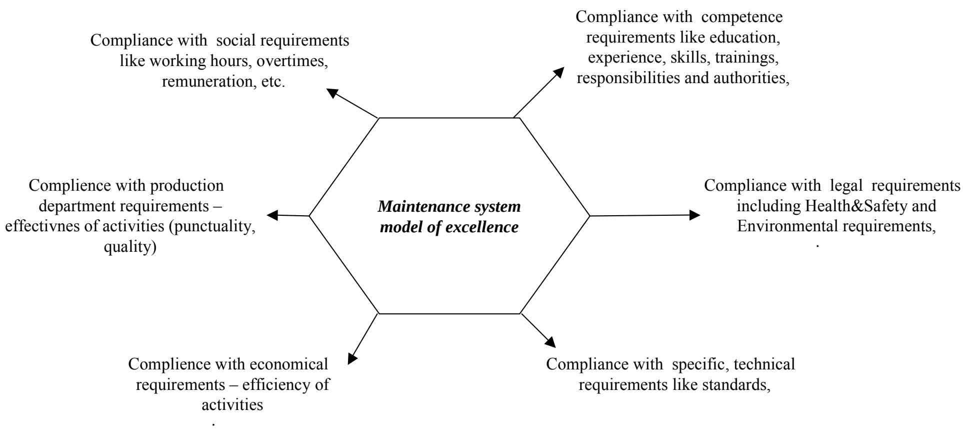

Figure 2. Model of maintenance activities excellence.

4. CHOSEN MODELS OF WEAR

Although modern technical diagnostics offers a variety of methods and tools for assessing the technical state, including visual methods, X-ray, ultrasonic and thermographic vibroacoustic, knowledge model wear of the machine or its parts is of paramount importance.

4.1. Model of machine degradation

The complicated process of losing the initial physical properties of the machine, which is a consequence of their long-term use, is particularly visible in operating machines and vehicles where one can see consumption of operational capacity of the machines, deterioration of mechanical properties and functional elements and components of machines. This occurs as a result of intensive usage of machines and the impact of an aggressive

environment. Therefore it can be concluded that degradation of machinery is a complex process and depends on the accumulation of the effects of different types of tribological processes (wear, fatigue, cracks, deformation, creep, etc.) [5].
Each of these processes depends on the intensity of impact loads, vibration, thermal conditions, humidity and pollution.
From the standpoint of assessing the degree of degradation machinery is important to determine the scope of utility resource depletion, or residual life. Admission to the continued operation of machinery used unrated their degree of degradation can be presented to the operation very costly and dangerous.
Approximation model for assessing the extent of degradation of equipment should include the assessment of the sustainability of the initial (design), estimate the impact of the history of forcing factors (including external load) and an estimate of residual life.
The process of degradation machinery is a long-time process and may be - in individual, relatively short period of time of observation - treated as a quasistatic process. In intervals of observation can be treated as a monotonically changeable process without a rapid disorders.
Based on the results of long-term experimental studies, considering the degradation process throughout the life of the machine, one selects the best approximating model.
Complex working machinery, filling out the functions provided by the manufacturer, are subjected to the inevitable process of degradation. In addition to the natural aging, the degree of degradation depends on technological factors, organizational and conditions of use.
Reasonable control of the operation of these machines, in addition to knowledge of the kinetics of wear of individual elements or functional groups, requires knowledge of the extent of degradation of the whole machine.
Analysis of machine degradation was performed on the example of a farm tractor.
321 tractors, the main brands available on the European market, used in large-area farms with adequate servicing and repair facilities were tested,. Average annual intensity of use of tractors ranged between 1000 - 1200h. . Technical assessments were made using an estimate of the tractor-experts, assessing visual functioning and history of the direct users. Estimates of the degree of wear undertook eight independent experts. The overall level of degradation, starting from degradation of individual components to the proper operation of the entire tractor. The degree of degradation of the tractor over years of operation is described as a logarithmic curve presented on figure 3 and defined by equation (1):

$$Z = 21{,}75 \ln t + 5{,}88 \quad ; \qquad R^2 = 0{,}97 \qquad \ldots(1)$$

Degradation of a tractor can be divided into two stages. The first, characterized by accelerated wear occurs to 9 years of operation. In subsequent years, consumption is also increased, but its intensity is much lower than in the first years of operation. This is due to perform a variety of service in the field depending on the operational forces. The course of degradation of the tractor is similar to the classical Lorenz curve of degradation.

4.2. Model of working tools (parts) degradation

Life prediction of working tools is characterized by two essential feature [6]:
- The value of degradation after a certain time,
- value of degradation in function of time.

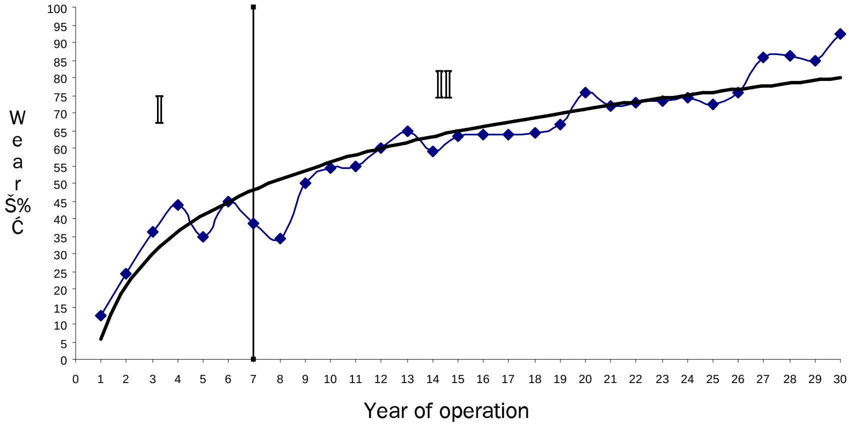

Figure 3. The course of degradation of farm tractor, depending on years of service.

Complex model of degradation in function of time Z (t) proposed by Balcersa and colleagues [6] can be represented as (2):

$$Z(t) = Z_o + Z_j \cdot t + b\int_o^t Z_w(t_s)dts \qquad ...(2)$$

where: *Zo - initial value of degradation,*
Zj - wear intensity,
b – coefficient,
Zw (ts) - processes showing a temporary deviation from the expected value of degradation.

Designation degradation curve, due to the lack of a unified theory, implies the need to look for empirical models. Exemplify the model of the kinetics of wear shown in the example of a tool working in soil, which was granulometric composition of sand gravel and clay medium in various states of moisture. (W). Variability of soil moisture pulp was dependent on soil type and ranged between 9 - 16%.

The study involved two different construction materials: steel 38GSA of microstructure of bainite and martensite, and welds trostytem Gridur 65 of the microstructure of ferrite alloyed with lamellar precipitates primary carbides and eutectic [α + (Fe, Cr) 7C3], and the fine carbides, Nb and W. The average hardness of steel - 460HV10, while the deposit 810HV10.
Working elements in the sandy gravel are consumed by the simple process of microcutting or striate, and in the case of clay-dominated medium multicycle fatigue with microcutting. Regardless of soil conditions, the course of degradation as a function of workpiece machined surface describe the linear dependence [5]. Thus, in the course of degradation is not possible to determine break-in period and analyzed model can be simplified by eliminating the random variable showing the wear after break-in.

5. CONCLUSIONS

Defining quality as a level of meeting the requirements, quality of maintenance can be seen as level of meeting requirements determined by Production Department by Maintenance Department. Presented in paper model of maintenance excellence assumes, that quality of maintenance consists of on such factors as effectiveness and efficiency of maintenance activities, compliance with lew, H&S and Environmental issues, compliance with competence and social requirements. Efficiency and effectiveness of maintenance activities depends on many factors. Used methods and diagnostic tools are one of the most important, having on mind, that diagnostic in the full approach it is also prediction of future technical changes. From the standpoint of rational decision-making concerning production planning, maintenance and repairs, forecasting technical condition is by far the greatest importance. Using by the maintenance services mathematical models of machines and their parts wear (as specified in the paper) allows to unddertake optimal - from Maintenance and Production Departments point of view– decisions concernings services, repairs or repalcement of machines or parts.

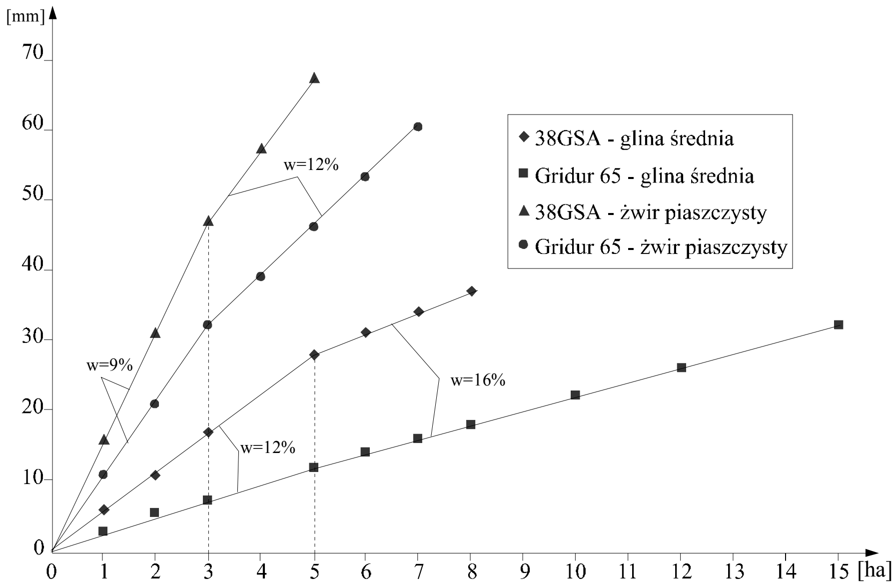

Fig.42. The course of wear a work item, depending on the external excitations.

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