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THE APPLICATION OF NEW INDUSTRIAL MAINTENANCE CONCEPTS - AN EASY WAY TO SAVING MONEY

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Abstract: *Since the beginning of the current millennium, various professional organizations, research institutes, scientific papers in journals and various conferences around the world, address the issue of maintenance, generically speaking, both theoretically, directly or tangentially and by examples of benefits in industry for various production processes, machines and installations. However, recent studies and reports reveal that even in highly industrially developed countries, company management aims to improve maintenance in only about 15% of cases for the next plan year. Why, this is the question? This paper will try to provide answers and even propose possible solutions to increase the applicability in industry of new concepts and theories of maintenance. The arguments used are less oriented on the technical side, they are mainly focused on the "money" indicator, close to the understanding of the company's senior management, i.e. on how huge material benefits can be obtained compared to the insignificant investment expenses.*

Key words: *Maintenance concepts, total productive maintenance, managerial decisions, implementation guides, productive efficiency, benefits.*

Primena novih koncepata industrijskog održavanja - jednostavan način za uštedu novca. *Od početka ovog milenijuma različite stručne organizacije, istraživački instituti, naučni radovi u časopisima i raznim konferencijama širom sveta, bave se pitanjem održavanja, uopšteno govoreći, kako teorijski, direktno ili tangencijalno, tako i primerima koristi u industriji za različite proizvodne procese, mašine i instalacije. Međutim, nedavne studije i izveštaji otkrivaju da čak i u visoko industrijski razvijenim zemljama menadžment kompanije ima za cilj da poboljša održavanje u samo oko 15% slučajeva za narednu plansku godinu. Zašto, ovo je pitanje? Ovaj rad će pokušati da pruži odgovore, pa čak i predloži moguća rešenja za povećanje primenljivosti u industriji novih koncepata i teorija održavanja. Korišćeni argumenti su manje orijentisani na tehničku stranu, uglavnom su usmereni na indikator „novac", blizak razumevanju višeg menadžmenta kompanije, odnosno na to kako se mogu dobiti ogromne materijalne koristi u poređenju sa beznačajnim investicionim troškovima.*

Ključne reči: *Koncepti održavanja, ukupno produktivno održavanje, menadžerske odluke, vodiči za implementaciju, produktivna efikasnost, prednosti.*

1. PRODUCTION LOSSES – HEAVY BURDEN – WHAT/WHO CAN REDUCE THEM?

There is no company, especially the new ones, that has not raised the issue of reducing all or some of the 8 categories of losses defined by T. Ohno [1] and maximizing productive efficiency. Failures in the attempts of firms to be more competitive are related to misapplication or non-compliance with application stages of more than 25 methods or tools dedicated to this purpose.

The multi-step regression model showed that Total Productive Maintenance, Poka – Yoke, Kaizen, 5S, Kanban, Six Big Losses, Heijunka, Takt Time, Andon, OEE, SMED and KPIs are the best tools for loss management, and of these, it has been shown that 5S, Kaizen, Kanban, Poka - Yoke and TPM are highly recommended for starting each initiative to make efficient a company [2].

This is how things stand, as in any enterprise and especially in the companies producing goods, maintenance or rather its lack is mentioned among the major categories of losses, we will focus on it.

1.1 What?

It is widely known that industrial maintenance is a knowledge intensive field based on different disciplines covering a wide range of technical sciences involved in the various technologies included in modern industrial equipment. Therefore, until recently, the complexity of the equipment and the need to have a knowledge bag corresponding to a very large area of science and technology was the main limitation of substantial improvements to the discipline of maintenance. In fact, innovative advances in support technologies are needed to enable maintenance engineering to fully develop its potential. In this respect, new ICT-based and microelectronic technologies - such as intelligent data capture, advanced viewing, wireless, IoT (internet of things) and intelligent sensors - provide maintenance with the environmental intelligence needed to renew the way forward maintenance [3].

The evolution of the field to which the task of preserving machinery and installations has come to be seen, in a general picture in figure 1, as having three well-defined areas: management and management of activities (Underground), workers maintenance and repair work (First Level) and Maintenance Intervention

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Objects (Workshop).

Workshop	Machinist Machine tool operator Worker
First Level	Maintenance operator in: - Pneumatycs - Hydraulics - Electronic - Computer - Chemistry - Mechanics - Technolgy - Electrical - Materials - Phisics - Math
Underground	* Head of the Maintenance Department * Material Basis, * Endowments, * Support Services

Fig. 1. The way of maintenance running in a company

The results of the company from the operation of machinery and installations are linked to the hopes of those who have their eyes and ears at every moment on how they "fight the productive but also the related and support sector, the administrative management compartments but more chosen patronage.

1.2 Who?

As you can see in figure 1, the maintenance operator, the one who had to repair and re-install the fallen equipment, has accumulated constant knowledge, has acquired skills and has perfected his technique continuously. This happened until he has not dealt with the constructive and functional complexity of the subject of its activity. The need to carry out the tasks led to the transition from a worker to a team of workers. Then he continued with qualifications centred on the types of actuation and control (mechanical, electrical, hydro-pneumatic, electronics) and more rarely on machine type and their subassemblies (gearboxes, transport systems and tracks, frames and elements of the resistance structure, spindles etc.).

At the same time, there has also been a change in the role of the teams: intervention, maintenance and supervision, repairs, etc. The coordination of the work of the teams has gone from the task of maintenance and repair to the maintenance department, which, with the change of name, has also received new tasks: planning, management, monitoring, control, prediction, design and development strategies modernization, etc.

2. MENTENANCE –A NECESSITY!

Over time, the usual wear of technical equipment makes their efficiency significantly decrease. The compensation brought by the amounts accumulated from the payment of depreciation must be supported by an adequate maintenance strategy, rational investments in advanced technological solutions for monitoring the technical condition of the equipment.

Even if the latter seem initially for the management of the company as an expense at least unproductive, if not useless, the long-term benefits far outweigh the risks of having a maintenance "by ear", eliminate stress and chaos from the maintenance activity.

At the same time, the advanced technique of real-time monitoring of equipment and digital management of maintenance activities is able to help managers organize the company, automate production lines, streamline routine maintenance operations, reduce consistent bills for the energy consumed and improve the operational safety standards of the company. There is no other way to increase your revenue and stay competitive!

Performing according to the schedules of the maintenance activities on the production equipment ensures their operation at the set parameters throughout the production cycle.

Carrying out maintenance late or superficially is an appealing strategy for a firm, because in the short term it will lead to financial savings. In the long run, however, this managerial decision will inevitably lead, in a first phase, to the operation of the equipment under parameters and then even to their failure. In both cases, the company will be negatively affected, on the one hand, by significant production losses, directly and visibly and on the other hand by additional indirect, hidden costs. In addition to the two components of losses, quantifiable in money, there is also the disruption of the way production is organized in the company, which leads to a poor mental state of the employees, an increased insecurity at work.

3. WHAT IS NOT SPENT, IS A SAVING, SO MONEY OBTAINED EASILY

One way to make money, honestly and unspeculative, is to produce and sell, so to do productive work, in short, to work. One way to save money is not to spend it, so not to take the money out of your pocket unnecessarily or, if it really is needed, not to pay faster than at maturity and in no case more than it does. The first way is a gregarious description of the work of a firm producing material goods. The other way is to present maintenance as a conservative activity of money and to stop unnecessary expenses.

Among the most important goals of any productive company is to ensure its own sustainability by continuously resuming production cycles, while recovering the initial investment costs, including those with the installation of equipment and additional ones to cover inflation, fiscal adjustments and the increase in prices of raw materials and energy.

The causes that generate a hidden amount of costs for productive companies, so we will be able to better understand the size of the savings that can be made only by rigorously complying with the maintenance prescriptions:

a) The quantitative decrease of the production – the non-operation to the optimal parameters, the unscheduled non-operational times for the production equipment, the frequent shutdown for carrying out unscheduled or accidental repairs seriously encumber the quantity of finished parts, disrupts the supply / shipping chain and the efficiency of the activity and the productivity of the operator decreases dramatically. The company's diminished revenues decrease even more due to the addition of additional costs with materials, spare parts and overtime paid to maintenance technicians or to a third party; so seriously diminished income!

b) Reducing the quality of production – a large part of the products no longer fall within the allowable tolerances or the prescriptions of the quality standards. Therefore, they are either scrapped, turning into waste that must be disposed of from the productive space, or they require reshuffles with additional expenses of time and workmanship or in the best case they are sold below the pre-calculated price. Whatever the case may be, the company's revenues are falling. The decrease in the quality of production has another adverse effect, namely, it affects the reputation of a company, which in the medium term can lead to the loss of customers; therefore, money wasted here too!

c) Failure to comply with schedules and schedules – due to the operating gaps of the equipment, both the production schedules and those of the related activities of preparing the production / dispatch of the finished products, etc. can no longer be carried out. The availability of equipment being subject to chance, there is no certainty of the correct realization of the schedules and the rescheduling are unpredictable, as uncertain become the supply programs established with the suppliers and the dispatching programs negotiated with the customers; So, the firm appears unserious and money wasted!

d) The decrease in the safety of the operator of the production equipment – the lack of specialized maintenance for long periods of time, the accumulation of bug fixes of the defects ("to turn the wheel") in conjunction with the normal deterioration in operation of the equipment can culminate in an accidental failure of major gravity both for the equipment and, unfortunately, for the human operator. The bills for repairing the equipment increase vertiginously and the medical, insurance and compensation ones for the injured operator become exorbitant. All these costs could be avoided by simple routine maintenance operations; so, other unplanned high costs and possible unwanted responsibilities!

e) The increase in the amount of penalties, fines and retraining - the failure of the economic operator to comply with the various prescriptions regulated by different authorities and national agencies or professional associations regarding the emissions of toxic substances, pollutants, the safety of the working environment, the protection of the human operator, the noise level, prohibitive consumers of, etc. is severely penalized. The inspectors entitled to check the compliance of the companies, for the lack of adequate maintenance measures of the facilities, order, in case of serious violations of the rules, the cessation of the company's activity. Most of the time, however, in case of non-compliances, the agents order important penalties and fines, in addition to obliging the company to carry out costly corrective measures before resuming production; So, not the small expense and danger of closing the firm!

f) Increased investment costs – an improperly maintained equipment will go out of the parameters faster, suffering, most often, irreparable damage and therefore requiring its premature replacement, before the end of the preconized life cycle. The more expensive the equipment in question or is in a critical position on the production line, the greater the financial losses of the firm will be. In addition, the decommissioned equipment, until its disposal, will occupy spaces in the company that do not produce but for which locations, rents and other expenses are paid. Because the equipment was not professionally monitored and no maintenance works were performed at the time, the damage of the company becomes consistent!

From the above it is clear that the adoption of a crash strategy or the postponement of maintenance, both seemingly very little expensive, in fact leads to an increase in operational costs, depreciates the quality of finished products, increases safety risks and can make the equipment irreparable, significantly shortening its life cycle and ultimately significantly increasing the damage of the company.

4. WHICH MAINTENANCE STRATEGY IS THE BEST?

The amount of money that companies spent yearly on maintenance can be as large as the net income earned [4]. Modern manufacturing systems generally consist of automated and flexible machines, which operate at much higher rates than the traditional or conventional machines. As a result of this higher utilization rates, automated manufacturing systems may incur four times more wear and tear than traditional manufacturing systems. The effect of such an accelerated usage consists in higher failure rates, which in turn would increase the importance of maintenance and maintenance-related activities as well as effective maintenance management.

While maintenance actions can reduce the effects of breakdowns due to wear-outs, random failures are still unavoidable. Therefore, it is important to understand the implications of a given maintenance plan on a system before the implementation of such a plan. In any case, the importance of maintenance function has increased due to its role in keeping and improving the equipment availability, product quality, safety requirements, and plant cost-effectiveness levels since maintenance costs constitute an important part of the operating budget of manufacturing company [5].

Most of the previous studies, which deal with maintenance modeling and optimization [6, 7], have concentrated on finding an optimum balance between the costs and benefits of preventive maintenance.
In this paper, procedures that combine analytical and simulation models to analyze the effects of corrective, preventive, opportunistic, and other maintenance strategies on performance of modern manufacturing systems are only mentioned in order to serve the best choice for the concrete company

So, returning to the question in the subchapter, the answer is not an easy one, nor can it be obtained without taking into account the size and specifics of the production in the company, the degree of automation, the state of the equipment, the qualification of the operating staff, etc. It is not the time, nor the place, nor does it correspond to the dese-so-stated purpose of this study, to try an answer of this kind. But we can make arguments to answer the question, which is the least expensive maintenance strategy and which at the same time, is suitable for most all firms, firms from the smallest to the largest.

Total Productive Maintenance – known by the acronym TPM – is the name of the maintenance concept that can easily bring money to any company, even if it only applies the 5S measures in the concept. Putting the TPM strategy into practice requires a minimum investment effort and a substantial managerial commitment to achieve amazingly good economic results in the end.

In order to substantiate the above statement, we present below only the result after one year of such an implementation of the TPM in an SME-type enterprise, completed in 2010. In the graph in Figure 2, the clues that were chosen to be designed and then monitored, measured and finally subjected to analysis are as follows:

- Ivy-Inventory;
- Wmp-Work in machining process;
- Mte-Machine tool efficiency;
- Lpt-Lead time order to product;
- Mst–Machine tool set time;
- Mlt–Manufacturing lead time;
- Ert-Equipment running time;
- Tsm-Time of matherials cycle;
- Cpw-Cost of product warranty;
- Cdi-Cost of direct & indirect labor;
- Pcs-Product cost;
- Opc-Overall productivity of entire capital

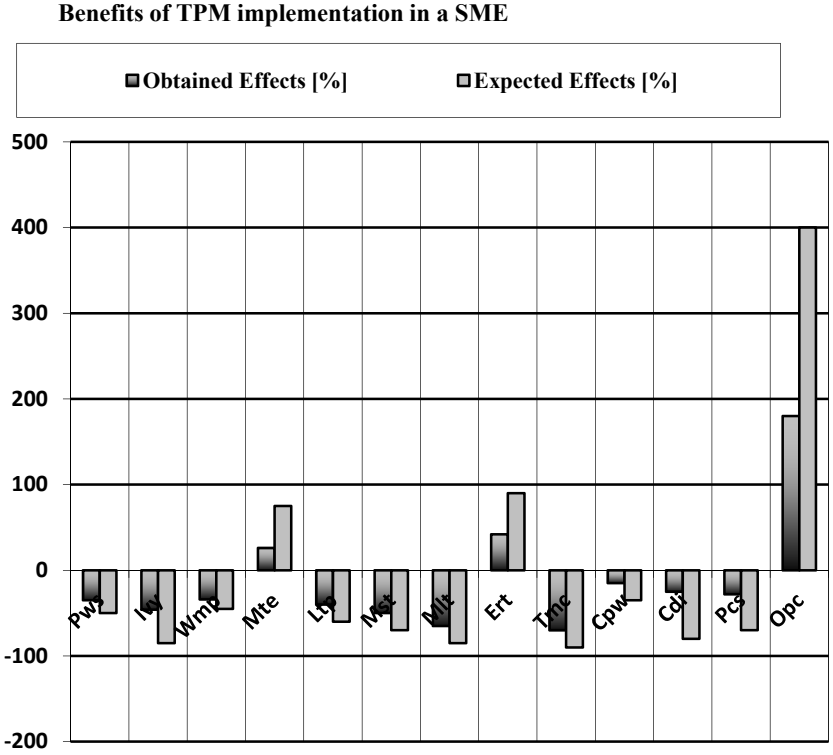

Fig. 2. The way of TPM running in a company

Briefly, the results shows in figure 2 contain both, the estimated benefits and the real one. In connection with this chart it can be easy to observe at a glance that for all compared indexes, the expectations are greater than the real results, be they above or below the horizontal axis.
The method of application, even if it is recently cited and characterized by the authors of a larger study (8(as a "conservative", it could not be challenged in terms of financial results – global savings of about 20% for the applicant company. It's like buying the dollar for 80 cents. Easy money, isn't it?

5. CONCLUSIONS

It is understandable the optics of the top managers, oriented on the profit of the company's activity, but it is incomprehensible that they do not pay due attention to the hidden costs (related to the decrease or stagnation of the production and its quality) and very hidden (related

to the satisfaction of customers but also of their own employees). A simple analysis of the sources of loss only on the maintenance side and their elimination or at least their mitigation by implementing the appropriate maintenance strategy, is certainly bringing savings. The investment is minimal if the strategy is based on the TPM conceptually or at least on an important part of it – the 5S measures. The result is not immediate, but after about a year it will be seen – money obtained easily! The experience of the practical activity in the field has shown us abundantly that in order to achieve good results, so easy money; there must first be a little sweat and patience. No stage of implementation should be skipped, no measure should be rushed, the procedures must be followed exactly and consultation with specialists is absolutely necessary – J.A. Comenius advised us that "the clairvoyance of a single person, no matter how penetrating it may be, gives the possibility of sneaking a mistake", therefore, teamwork is a sine qua-non condition in such situations.

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