THE EFFECTIVENESS OF THE IMPLEMENTATION OF NEW MANAGEMENT SYSTEMS IN MAINTENANCE FOR METALLURGICAL PRODUCTION

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Abstract

Currently still prevailing system of maintenance - repair after failure. This maintenance management system demonstrates the deteriorating state of the production facility in metallurgical, but also other factories and increasing level of repair costs. Yet many companies remain at this management method, mistrust economic impact and return on new systems, and particularly fear the high cost of implementation of systems like TPM into practice. Maintenance management is part of every production system, including metallurgy. This creates a need to find a simple and understandable mechanism that helps the decision making process of changing the approach to maintenance management, and demonstrating its economic benefits. The aim of this paper is to draw conclusions from extensive study of maintenance expensiveness of metallurgic services and solution of this problematic by implementing of TPM system.

Keywords: Maintenance, TPM, TIM, system costs, losses, efficient, saving, metallurgical production

1. INTRODUCTION

In recent decades maintenance management system experienced an important development in the theory. Troubleshooting system (BM - Break-down Maintenance) was gradually overcome by preventive maintenance (PM1 - Preventive Maintenance) productive maintenance (PM2 - Productive Maintenance), total productive maintenance (TPM - Total Productive Maintenance) and maintenance-oriented reliability (RCM - reliability Centered Maintenance).

But business in the area of maintenance management did not experience such similarly dynamic process of development and largely remained in the maintenance phase after failure and preventive maintenance in periodic cycles. The cause appears to be relative lack of financial resources allocated to maintenance and often subjective reluctance to implement systemic change in an area that is not directly involved in manufacturing production.

Surpassed, but in practice still prevalent system of care for long-term assets consumes considerable resources, reduces the level of technical state of machines and production equipment, limiting its performance and reduces competitiveness. While the introduction of modern management mechanisms in maintenance would clearly bring significant cost savings and contributed not only to improve profits, but also to better utilization of investment in maintenance, reducing downtime in production and increase production quality. [1] [3]

2. COMPARISON OF THE CORRECTIONS SYSTEM AFTER A FAULT AND TOTAL PRODUCTIVE MAINTENANCE

To demonstrate the benefits of the introduction of modern management mode maintenance is necessary to understand the differences especially in principles of troubleshooting (BM), preventative maintenance (PM1), productive maintenance (PM2) and total productive maintenance (TPM) [1]:

System troubleshooting (BM) - only after a breakdown or accident occurs equipment troubleshooting. Removal of serious failures or accidents usually involves high costs and a significantly longer time to remove them.

Preventive maintenance system (PM1) - in periodic cycles (the first option), or after the detection of device status (the second option), in the period between the purchase of equipment and overhaul, preventive maintenance is performed. The problem is to determine the cycle and thus often unnecessary replacement of parts, which still do not require replacement.

The system productive maintenance (PM2) - maintenance is conducted not only to maintain equipment in working order, but eliminating impacts on the production process (production quality, delivery times and production costs) is taken into consideration.

The system of total productive maintenance (TPM) - the objective is to maintain the production equipment in optimum condition and maintenance is understood comprehensively, thus proactively - with regard to efficiency in use, preventive and predictive (with the shutdown and without shutdown), with the participation of not only the maintenance staff, but even with the involvement of equipment operators.

TPM thus comprehensively includes servicing - in addition to regular service friendly service and also service with subjective diagnostic activity, as well as maintenance - especially diagnostic, and only limited preventive and periodic preventive service due to age. Repairs after implementing TPM should be restricted to replacement of wear parts and other standardized interventions that can hold assets for a maximum uptime.

3. COMPARISON OF COST STRUCTURE MAINTENANCE SYSTEMS

The introduction of TPM eliminates serious failures and accidents, reduces production losses caused by the exclusion of the production installations. It also allows the production limitations of poor quality to a minimum. On the other hand, at the time of the introduction of TPM there may be a slight increase in maintenance costs, the introduction of diagnostics, which are designed to detect the wear of the components device or other anomalous activity in machinery and equipment. Furthermore, it should implement operator-friendly elements, which in current systems maintenance management are not addressed systematically. Operation is often not motivated. [3]

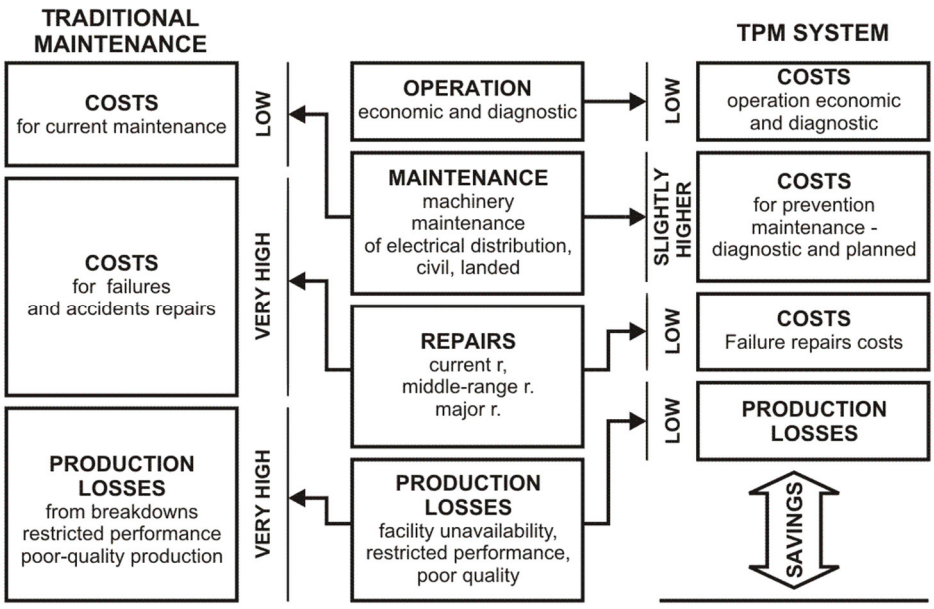

Figure 1 Saving effect due to TMP implementation

The introduction of TPM according to studies conducted in the overall result has a significantly positive effect in terms of improving the management of maintenance in the economic field. The **Figure 1** shows the effect of savings.

3.1. Calculating of the benefit of the introduction of total productive maintenance in practice

Economic benefits from streamlining maintenance processes can be generally expressed as improve profits by increasing revenues and cost optimization (see **Figure 2**). [6]

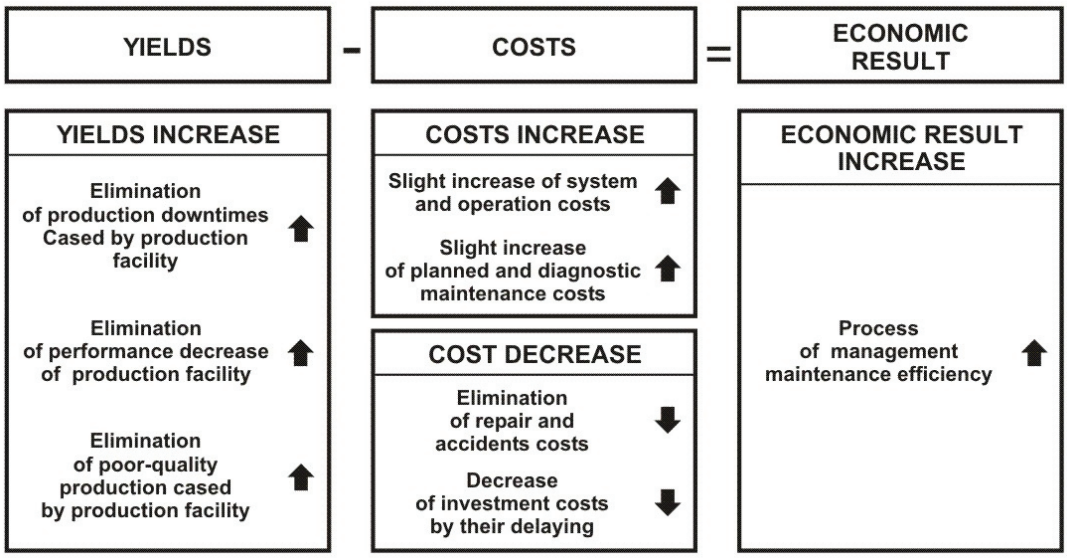

Figure 2 Diagram of the effect of introducing TPM savings in maintenance management to profit

Increasing yield is achieved by eliminating downtime in production due to the decommissioning of production installations, preventing a decline in its performance and poor quality production constraints caused by poor operation of the machine.

Cost optimization is then achieved by limiting the emergence of failures and accidents, and thus increasing the uptime of machinery and equipment, possibly reducing the need for investments or delaying them. On the other hand, the implementation of TPM in the management of the maintenance process, especially at the time of its introduction, brings new costs, such as training of machine operators, investment in equipment for diagnosis and Software equipment or security diagnostics outsourcing, but overall lower level of total maintenance costs should be achieved.

Quantifying the economic benefits of the implementation of TPM involves comparing the costs associated with maintenance at present compared to the projected maintenance costs in accordance with the principles of TPM. The basic cost of the two systems are compared in the following **Figure 3**.

Management maintenance system costs

Maintenance management system is not software supported in the number of companies. If some companies apply software for maintenance management, it is often not fulfilled the objective information, or its possibilities are not fully exploited. Almost all currently offered software systems lack control modules and security parts and modules for standardization of maintenance tasks, including an assessment of their labor. It is not an unusual situation, when the company does have the software for maintenance management, but this system fills data from the implementation of practices that are not always objective and, moreover, are not carried out an analysis of actual maintenance intervention. Implementation analysis is an essential component for improving any action, especially maintenance management.

Costs of operation involved in maintenance

The vast majority of companies are not set up correctly to be motivated for careful operating of machinery and equipment, and therefore often arise fault and accident such extreme loading of the production facility or other improper use. While the involvement of employees in production system friendly service and their motivation is the basis for a substantial reduction in maintenance costs optimal utilization of operating parameters of machines and equipment, the elimination of extreme loading or other forms of improper operation causing damage. Operator involvement in maintenance, whether through perceptual diagnosis or some simple tasks associated with maintenance (lubrication, cleaning, etc.).

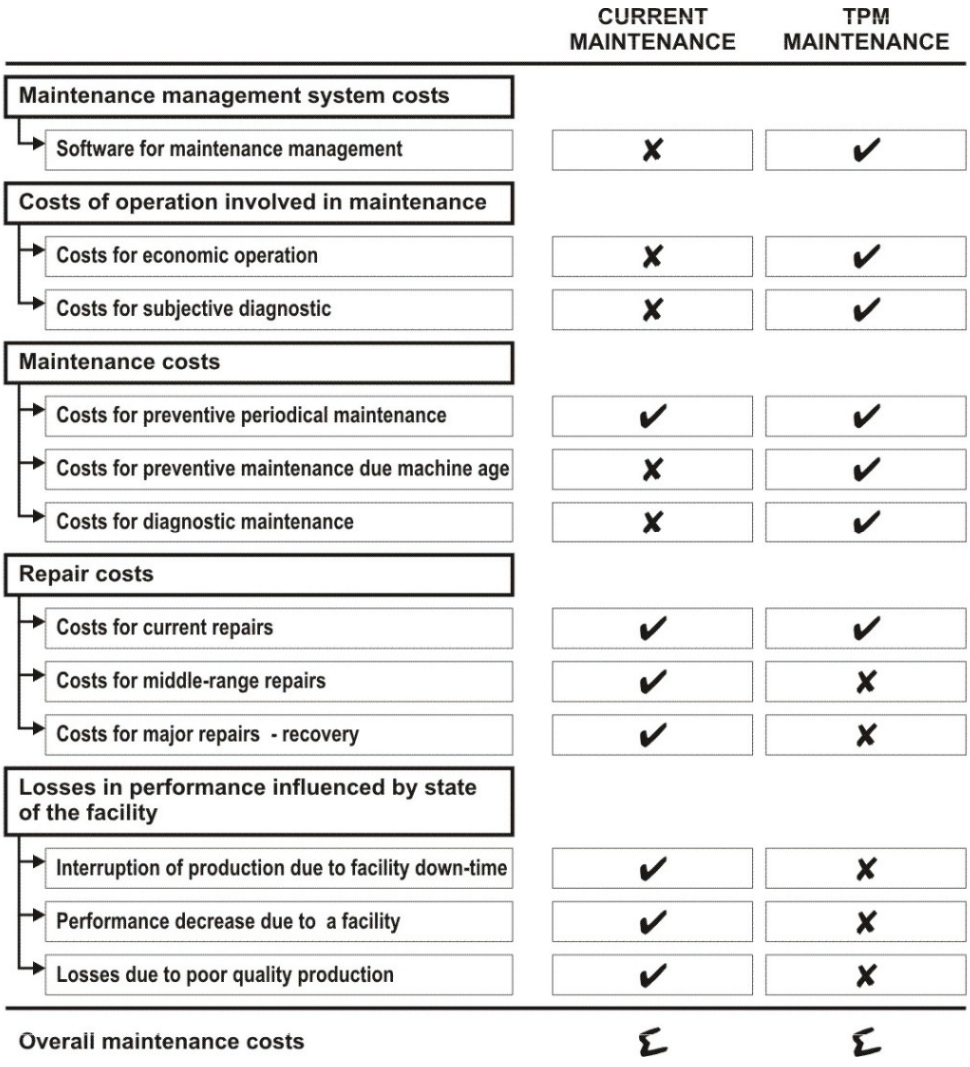

Figure 3 Comparison of the cost of routine maintenance and TPM

(Explanation of symbols used in the figure: ☑ - load is represented in the system; ☒ - expense is not represented in the system)

Maintenance costs

The traditional system is based primarily on the principle of periodic preventive maintenance, according to predetermined intervals or according to the age of the machine. Therefore, it does not reflect the actual condition and maintenance is performed unnecessarily when the device is completely fine, or too late, when the machine is already showing serious damage. Implementation of technical diagnosis is able to control the

timing of maintenance action at the very moment when intervention is desirable to limit and incur costs to a minimum and make them more efficient.

Repair costs

The current maintenance system is not able to prevent failures and extensive accidents. This usually results in huge costs to repair and enormously burdens corporate economy. Timely diagnosed anomalies in terms of the smooth operation of machines and production equipment, and its early removal, the emergence of failures and disaster proved wholly or largely eliminated. The vast majority of failures caused by the human factor could be avoided in case of TPM application.

Loss in performance affected by the device condition

The emergence of failures and accidents usually has a significant impact on either the performance of the manufacturing facility, or to complete its decommissioning, often long term. Also, it may happen that the effect on production machines outside the optimum condition is poor quality production. And it leads to loss of income, failure to comply with deadlines or later complaints.

Figure 3 shows a general comparison of the cost of traditional maintenance system ZPM. Theoretically expected and by practical studies validated difference of totals cost elements of both systems, speaks clearly in favor of TPM.

4. EXPERIMENTAL VERIFICATION OF THE ECONOMIC BENEFITS OF TPM IN THE PROCESS OF METALLURGICAL PRODUCTION

The effectiveness of the implementation of the principles of TPM has been experimentally verified at three sites of metallurgical operations in Vítkovice Heavy Machinery Inc. - Steelworks in NS 320 and NS 340 Forge.

For LF electric ladle furnace 80 tons has been shown that the introduction of proactive maintenance would most likely managed to avoid a serious accident of a transformer, whose correction required costs over 8 millions CZK and a long-term shutdown of the entire plant furnace caused a loss in production in hundreds of millions CZK.

With the electric arc furnace EOP no. 5 (NS 320) and vehicle heating furnace no. 2 (NS 340) were detected significant losses arising from the absence of ongoing analysis which led to the multiple recurring malfunctions and accidents. They were mainly the issue of pulvit hoses and oxygen feed, or malfunctions in the heating system. Repair costs did not reach high values, but their frequency and shutdown of furnaces significantly restricted the technological production process.

Overall, in the period of 4.5 years, 2719 accidents were analyzed in terms of the causes and consequences of breakdowns. There were estimated losses caused by disorders of almost a hundredfold compared to the cost of implementing TPM merely on LF electric ladle furnace

It can be stated that the vast majority of the costs and losses caused by the emergence of failures and accidents that were investigated in the experiment, it was possible to eliminate using the TPM. A serious lack of current practice in the operations of steel mills, forges, foundries and other metallurgical plants is insufficient data evidence in terms of maintenance management. Furthermore, absence of diagnostics, scheduled maintenance, optimized inventory management for maintenance and lack of staff motivation for careful operation is apparent. The absence of any failures and repairs analysis and not introducing any measures to prevent their recurrence can be indicated as the crucial fault.

Faults in the maintenance facilities surveyed - LF electric ladle furnace, electric arc furnaces and chariots heating furnace are (as the investigation established) also typical for the metallurgical facilities in the company.

5. THE DIRECTIONS OF FURTHER DEVELOPMENT OF THE OVERALL MANAGEMENT SYSTEM INCLUDING MAINTENANCE MANAGEMENT SYSTEM

Further development of management system aims at future factories i.e. digital factories. Digital factory can be characterized primarily as a virtual image of the real production system controlled by computers and software. Often already developed methods and techniques of software can display manufacturing and other related processes that occur or may occur in the manufacturing and other systems.

Digital Factory in the Czech Republic is so far considered to be a vision or even fiction of future development. In the advanced industrial world, there are certain specific signs of partial solutions already known. Future factories are the subject of the research program announced by the EU - "Horizon 2020". Digital Factory is a concept for a comprehensive system that covers an extensive network of digital methods, different models and tools that are built for continuous data management.

The aim is a comprehensive and systematic planning, design, verification and continuous improvement of production structures, manufacturing auxiliary and service processes including resources in relation to production program. Maintenance is an auxiliary process of each production system, and must be part of a comprehensive integrated management system.

This article was based on studies demonstrated indisputable advantages and effectiveness of the implementation of TPM into practice manufacturing companies. According to our ideas TPM and its component parts (data base management system and spare parts), which are resolved at the Technical University of Ostrava, will be an integral part of the future of digital factories.

Currently we have resolved theoretic maintenance management system that can be integrated into enterprise management system (ERP system, such as. SAP, IFS, Conn., Etc.). TPM integrated into enterprise management system creates a system of TIM (Total integrated maintenance). [4] [5]

Characteristic of TIM:

1) Records of all machinery and equipment kept on a computer - IFS and graphic sorting system.
2) Acquisition of "biography" of the machines and devices that deliver what is to certify them and what are their weaknesses, how often they are repaired and what constitutes a normal load of repairs - IFS and graphic sorting system.
3) Planning repairs with elaborate preparation (option periods matched with production tasks, preparation of spare parts and components, etc.) - IFS and CAS.
4) Planning of purchasing, tracking and mainly destocking (a repair-maintenance equipment and material) - CAS and IFS.
5) Mentoring serving workers, their training and cooperation with servicemen, integration of operation and maintenance of their workload, a commensurate increase in their wages) - company maintenance.
6) Deepening the sixth concurrency of operation, maintenance, inspections and repairs - company maintenance.
7) Regular analysis of the results from different perspectives (operational, supply, accounting, etc. ...) - IFS, CAS and company maintenance.
8) Drawing conclusions for the organization of the operator, maintenance-repair work, maintenance and repair departments, metrology, collaboration with external services and laboratories - IFS, CAS, Graphic sorting system, company maintenance.

During other solutions in the field of research and development of system maintenance we will deal mainly with the expansion of the data base for the maintenance and improvement of its integration into specific management systems (ERP). [2]

6. CONCLUSION

In companies often prevails a view that investment in change of management system is expensive, and its return is uncertain. Its limited resources allocated to businesses prefer to purchase new fixed assets, while maintaining deemed unproductive and associated costs for inefficient.

It is true that maintenance consumes a considerable amount of resources. Some business sources claim their share of the total operating costs of 15 to 40 %. These costs are usually included items that are necessary to ensure the operation usually after the occurrence of accidents. When introducing maintenance management system with application of TPM can be expected, and this study demonstrated that all great incidents and accidents could be avoided. Therefore, considerable costs that must be incurred to relaunch machinery and equipment in working condition after the crash, are needlessly expended items. In addition, the biggest losses are for the company long-term outages of production equipment due to accidents.

It is therefore necessary to think about the maintenance management system, and invest money in maintaining the optimal level and with maximum effect.

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