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IMPLEMENTATION OF THE PRINCIPLES OF TPM IN FIELD OF MAINTENANCE
PREPARATIONS

IMPLEMENTACE PRINCIPŮ TPM DO OBLASTI ÚDRŽBY PŘÍPRAVKŮ

Abstract

Total Productive Maintenance (TPM) is one of the ways to ensure efficient production processes. TPM is primarily associated with the management of maintenance of production equipment. This article deals with the possible implementation of total productive maintenance in other field of maintenance of working means, and it the maintenance of preparations. Experience from practice shows that TPM approaches may be suitable for the maintenance management in this field. In this article are stated the conclusions drawn from the implementation of the principles of TPM in a concrete enterprise having available about 14,400 preparations.

Abstrakt

Totálně produktivní údržba (TPM) je jednou z cest, jak zabezpečit efektivní výrobní procesy. Je primárně spojována s řízením údržby výrobních zařízení. Článek se zabývá možnou implementací totálně produktivní údržby do jiné oblasti údržby pracovních prostředků, a to do údržby přípravků. Zkušenosti z praxe ukazují, že přístupy TPM mohou být vhodné i pro řízení údržby v této oblasti. V článku jsou uvedeny závěry, které vyplynuly ze zavádění principů TPM v konkrétním podniku, který disponuje cca 14 400 přípravky.

Keywords

TPM, Preparation, Kaizen, Maintenance, Planning, Visual management

1 INTRODUCTION

The technological sophistication of the machinery devices and their automation and robotization help to accelerate production processes and their efficiency. Management of companies with regard to the funds expended into these devices requires a reliable and efficient functioning of these devices and increasingly is directed towards the total productive maintenance. TPM into the future means an inevitable process. High costs and losses due production outages caused by the

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functioning of systems based mainly on repairs after failures are unsustainable in a competitive environment.

Some international surveys show that the cost of maintenance and repairs (incl. cost of warehouse management and here tied up capital) can amount up to 25% of turnover and 15% - 40% of total operating costs of the company [1].

The rate of development in the field of maintenance management is not directly related to developments in the production sector. One of the few approaches to remedy is the implementation of TPM (for some of philosophies). TPM principles are elaborated in a number of studies, but still have lack of sufficient experience in their practical implementation. TPM is a specific approach that is specific in its universality and paradoxically also in its great individuality in its implementation. Companies are focused on other areas, use other methods, other machinery and equipment and tend to employ staff with different skills, experiences and personalities like. Implementing TPM in companies is quite difficult, no matter whether they have their own procedures introduced, or not.

2 TOTAL PRODUCTIVE MAINTENANCE

TPM does not only deal with early detection of possible errors, but also reduces errors of short downtimes, e.g. when replacing parts or tools. TPM basic principles are as follows:

1. Evaluation of the overall efficiency of machinery and equipment - indicators of the overall effectiveness OEE,
2. autonomous maintenance - initial cleaning, eliminating sources of pollution, standards of cleaning and lubrication, preparation for inspections, autonomous check, organization and the good order, development of autonomous maintenance,
3. planned maintenance - determination of maintenance priorities, elimination of bottlenecks, building up of an information system, the beginning of scheduled maintenance, increase in performance of maintenance, improved maintenance and scheduled maintenance program,
4. a system for designing preventive maintenance and timely management of facilities - product development, concept of facility, construction design of facility, production of the facility and its installation, start-up and operation of equipment,
5. training to improve the skills of workers - knowledge, TPM basics ,TPM tools, team communication, autonomous maintenance, planned maintenance, knowledge of production. [2]

Unlike the traditional maintenance, through the total productive maintenance all employees of the organization are involved in system of maintenance and they communicate with each other when tackling the arisen problems. TPM solves especially the elimination of interruptions of production equipment (i.e. a shift from preventive to predictive maintenance) and increase in its productivity (proactive maintenance) and therefore it means the way of reducing costs. [5]

Implementing TPM brings many benefits - lower costs, shortening of manufacturing times, improvement of the processes, motivation of workers and reduction in equipment failure rate. All these benefits have an impact on increasing the competitiveness of the company. [7]

Preparations can be understood as a kind of tools, often of single-purpose tools that facilitate assembly or disassembly, handling the products or specify the correct dimensions of the product etc. In many cases, preparations become a part of the equipment and enable that the universal device can fulfill the function of a single-purpose device. The preparations, as well as other working means, deserve due attention.

2.1 Components of the Total Productive Maintenance

Autonomous maintenance is carried out operators and not specialized maintenance techniques. The operators take greater responsibility to perform preventive maintenance tasks themselves. Implementing autonomous maintenance is progressing slowly, step by step. First the operator must get a feel for faults detection and their anticipation. He can handle the basic tasks immediately, but more specialized tasks must be performed by maintenance workers. He can obtain information and gain experience from them. The operator will cost at the device, so he can detect fault or remove it immediately, or may contact the authorized person. This reduces the downtime, as in the device will cost operator that can detect a defect immediately eliminate it, or can call the authorized person. This will reduce the unplanned downtime.

Planned preventive maintenance is focuses on the creating an effective system of planned maintenance operations. They must keep a stable production process. Maintenance specialists focus on these activities. The equipment must be checked, make revisions, diagnostics, components replacement and inspection. Specialists also monitor other outputs such as weekly reports, recording costs, the number of produced parts etc. The efforts spent on administrative activities will be reflected in reliability and continuity of production. [2] [3]

Visual management is technique for communication by using visual signals. Visual management is primarily used as a tool for standardization and organization. Workers will simplify the work by correctly applied this technique. It allows for less skilled workers to perform more complex tasks. A common phenomenon is the use of TPM boards, cards and marking disorders (directly on the device by means of pictograms or algorithms). The standardization, information, education, comparison, uncomplicated management and motivation are the main outputs. An important method of visual management is Poka Yoke, which accelerates work using shapes, colors and markings. [8]

Kaizen means continuously improve. First we must improve ourselves, relationships with co-workers and only then can we change work processes. The basic elements include work ethic, personal discipline, teamwork, communication and suggestions for improvements. In keeping with Kaizen methods it is very important to pay attention to every detail, because it is the beginning of success. We cannot make big jumps in processes must gradually work to gain the set goal. Partly transfers the responsibility of senior management to middle management, supervisors and operators. [3]

2.2 Example of implementation TPM principles in the field of maintenance of preparations

For implementation was chosen an industry organization having available about 14,400 preparations. According to the management ideas all preparations should be in 100% status and ready for immediate use, but the internal data of the company did not confirm this idea. It was found that the poor maintenance of preparations caused to company annual financial losses amounting to millions (8 million in the year 2015 and 11.5 million CZK / year in previous years).

Analysis of the preparations was carried out for the period 2009 - 2013. Frequency of using the preparations in a given period for each type varies. Frequency of use ranges between 1-50 299 times during the monitored period. Scatter of frequency of use was quite large. It was carried out the analysis of preparations utilization, hand-over of preparations, maintenance of preparations (preventive and autonomous maintenance), storing of preparations and their handling.

The analysis of the current status showed following deficiencies: poor storage, insufficient lubrication, improper handling, storage of products metal to metal, non-cleaned preparations and use of damaged preparations, seasonally adjusted preparations and use of damaged products. The mentioned shortcomings were the consequence of the direct and indirect causes. Direct causes are the non-observance of principles of 5S method, of teamwork, of autonomous check (of maintenance) of an incomplete database of preparations or system of preparations handover and the indirect causes

include an ineffective educational system for operators, the absence of visual management or motivation of employees.

Division of the planned maintenance

Due to the large span of frequency of using preparations during the reporting period (1-50 299 per 5 years), based on consultation with the engineering were made two elimination changes. The interval was selected in a range of 500 (uses) for the most exploited type of preparation. For graphic design was used histogram. The process of calculation of histograms with an interval of 500 included the calculation of the variation range, determination of the number of intervals, calculation of the width of the interval, selection of the lower limit of the first interval and determination of the lower and upper limits for all intervals.

The first elimination amendment (change) meant the conversion in case of first 30 intervals containing 14,334 preparations. The remaining 430 intervals contained only 64 preparations.

The second elimination change for the formation of the division was the creation of a group of preparations that have been used only 5 times or less since 2009. This change defined in such a way has formed a group of preparations that undergone the process of conservation.

Summarization and division into groups

Preparations of the second elimination were divided into 4 groups (A, B, C, D) in Tab. 1. The table lists suggestions for the period of preventive maintenance. Each operator was properly trained and can handle the planned maintenance alone, without the help of experts from maintenance. Guidance on how to perform planned maintenance were given by the protocol of the company.

Tab. 1 Division into groups according to the period

Group	Time period (month)	Interval	Number of preparations [pcs]
A	Conservation	Utilization ≤ 5	1 479
B	12	1.	6 778
C	6	2. – 3.	3 473
D	2	4. – 30.	2 668

Suggestions for improvement

In response to the carried out analysis were prepared the suggestions that should have a positive impact on system of management of preparations in an organization with a direct impact on savings in financial resources of the organization.

For operators was designed the **graphic algorithm** on Fig. 1 (simple instruction) placed on the operator's workplace, according to which should be achieved an improvement in maintenance of preparations. The preparations are visually inspected before start of the working act and also after the termination of the working act. The preparation in both cases is absolutely fine and is always ready for subsequent use. The proposed solution falls within the field of autonomous maintenance.

Within the preventive maintenance in the company was **introduced the system of labeling preparations with barcodes**. The barcodes were entered into the software of the company. Through this step was ensured the check of flow of preparations. The system also contains the photographic documentation of preparations and their detailed description. Photographs and detailed description serve for a more effective control of preparations in case of their hand-over (warehouse – operator, operator - warehouse).

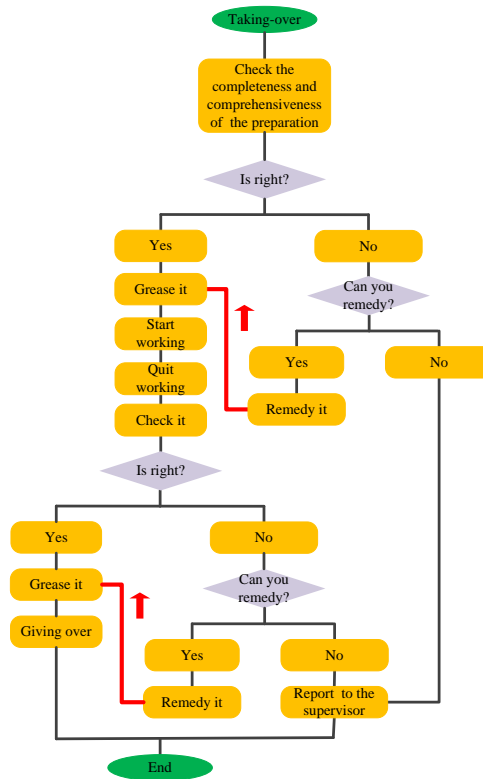


Fig. 1 Graphic algorithm – the procedure for autonomous maintenance [6]

On the basis of frequency of use of preparations the system evaluates the deadline of regular preventive inspections and maintenance of preparations. This division is compiled according to the histogram (Fig. 2). The histogram contains 20 intervals. For each interval is prescribed a certain number of preventive inspections per year. The higher is frequency of use in an interval, the greater is the number of annual inspections.

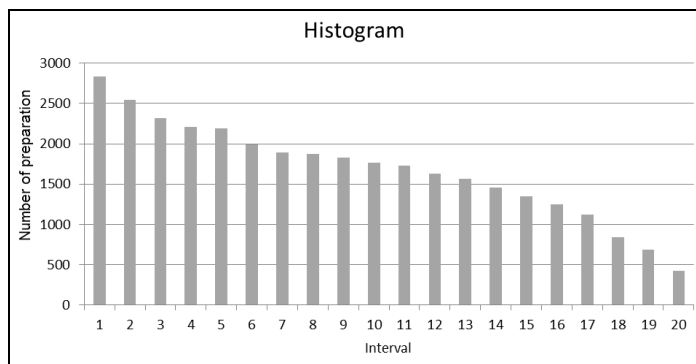


Fig. 2 Histogram [6]

In order to facilitate visual inspection of preparations were designed the **pictograms** depicting the concept and visual communication. The task of pictograms task was to inform operators about the number of components of preparations and about the critical point of preparation and its point of lubrication. The pictograms as tools for improvement of autonomous maintenance were processed in three different reflective colours with specific labels. Pictograms were placed at suitable locations, in order to meet their task completely.

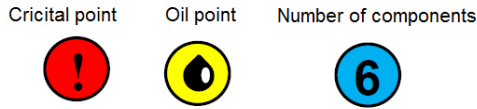


Fig. 3 A reflective pictograms [6]

- **Implementation of pictograms in practice**



Fig. 4 Implemented pictograms [6]

As a precautionary measure in order to determine whether the preparation during handling fell to the floor or suffered a greater crash, was proposed to use **crash sensors**. If the preparation suffered an impact, it must be completely inspected, because damaging could have occurred. The sensor is installed on larger preparations and for the location of sensors is responsible the maintenance sector. The sensor is positioned at a suitable location, i.e. where the impact is maximally sensitive.

If the preparation is not exposed to any other greater impact, the colour of sensor remains white (Fig. 5 - A1). Otherwise (Fig. 5 - C3) sensor turns red and the preparations must not be used for work. The operator immediately reports the situation to his supervisor and on the section of metrology. If the sensor is missing (Fig. 5 - B2) the operator again must inform his superior.

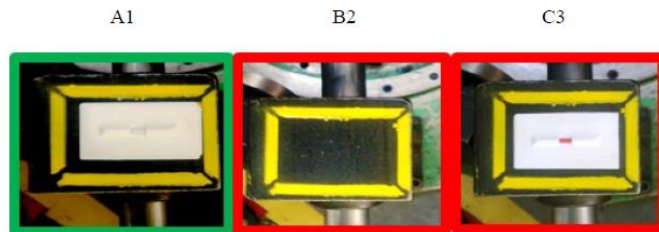


Fig. 5 Crash sensory [6]

The company indicates that into the implementation of TPM (in above stated extent) was invested the amount of CZK 2.3 million.

3 CONCLUSIONS

The Total Productive Maintenance is defined as maximization of the overall efficiency of machinery and equipment, it means as the way to eliminate failures and downtimes. TPM does not concern only the machinery and equipment, but its true purpose consists in the work with people in order to minimize the input and to maximize the output. The operator of the given machine is no more only a production worker, but he must know his machine and must be able to keep not only the machine, but also its accessories in a good order. In modern times of increasing the productivity of maintenance there is no more the space for the traditional distinction between production operator and worker who maintains the equipment. [2]

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. [4]

The organization that was subject to the study, has confirmed the implementation of the principles of TPM in the field of maintenance of preparations as successful. Thanks to the implementation of the proposals was increased the efficiency of maintenance of preparations. The funds expended for the implementation of individual proposals amounting to CZK 2.3 mil., due to the high financial losses caused by poor maintenance system of preparations in individual years are a reasonable investment whose return is in the order of months.

In this case through the results of implementation of TPM principles in the field of the maintenance of preparations was confirmed not only the timeliness of solving this issue, but also the possibility of using these principles in this area.

REFERENCES

- [1] HEIZER, Jay H a Barry RENDER. *Principles of operations management*. 8th ed. Upper Saddle River, N.J.: Prentice Hall, c2011, 1 v. (various pages). ISBN 01-361-1446-6.
- [2] LEGÁT, Václav a kol. *Management a inženýrství údržby*. 1.vyd. Příbram: Professional Publishing, 2013. 570 s. ISBN 978-80-7431-119-2.
- [3] KOŠTURIÁK, Ján a FROLÍK, Zbyněk. *Štíhlý a inovativní podnik*. 1. vyd. Praha: Alpha Publishing, 2006. 240 s. ISBN 80-86851-38-9.
- [4] NEČAS Libor a Josef NOVÁK. *The effectiveness of the implementation of new management systems in maintenance for metallurgical production*. In METAL 2016. 25th International Conference on Metallurgy and Materials : conference proceedings : May 25th-27th 2016, Hotel Voroněž I, Brno, Czech Republic, EU. Ostrava : Tanger, 2016, ISBN 978-87294-66-6.
- [5] NEČAS, L. *Výzkum a studie ekonomické výhodnosti implementace TPM do praxe: autoreferát disertační práce*. 1. vyd. Ostrava: VŠB - Technická univerzita, 2013. 110 p.
- [6] ZMEŠKAL, P. *Zvýšení efektivity systému údržby přípravků v konkrétním podniku implementací vybraných metod TPM: bakalářská práce*. Ostrava: VŠB – Technická univerzita Ostrava, Fakulta strojní, Katedra mechanické technologie, 2014, 62 s. Vedoucí práce: Gregušová, M.
- [7] DOGRA, M., SHARMA, V.S., SACHDEVA, A., DUREJA, J.S. *TPM - a key strategy for productivity improvement in process industry*. 2011, Journal of Engineering Science and Technology, 6 (1), pp. 1-16.
- [8] BESEDOVÁ, H., SMUTNÝ, L. *Principles of the Lean Company*. Sborník vědeckých prací Vysoké školy báňské - Technické univerzity Ostrava. Řada strojní, 2009, roč. LV, č. 2, s. 7-11.