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THE IMPACT OF LEAN MANUFACTURING ON THE NUMBER OF FAILURES IN A METAL INDUSTRY PRODUCTION PLANT – CASE STUDY

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The article presents the results of an analysis of the impact of selected Lean Manufacturing tools on the number of failures occurring on the example of a production plant from the metal industry, specializing in the production of welded pipes. Reducing the failure rate of individual devices on the production line is one of the key factors determining the efficiency of the production process and the quality of the manufactured product. In order to reduce unplanned machine downtime caused by failures, various techniques are introduced to reduce them, for example TPM (Total Productive Maintanance). The purpose of this article is to conduct a statistical analysis to assess the impact of TPM implementation on the number of reported failures on one of the production lines.

Key words: seamed pipes, failure, statistical analysis, Lean manufacturing, total productive maintance

INTRODUCTION

Due to the increasing competition on the market, a key factor for the manufacturer is to create conditions that allow for maximizing production capacity while maintaining the highest quality of the product. One of the organizational solutions that allows for the elimination of various types of waste is the implementation of selected Lean Manufacturing (LM) tools in a production company. Lean Manufacturing is defined in the literature as a technique aimed at reducing or eliminating waste [1-4].

The implementation of techniques included in LM is a response to the increasing complexity of management processes leading to high waste through activities that do not create value for the customer. The concept of lean management aims to eliminate most activities that do not add value to the product when producing products or services. At the heart of this theory is the desire to increase profit by focusing on costs. In the literature on the subject, seven basic types of waste can be distinguished, including: overproduction, unnecessary movement, waiting, unnecessary transport, inventories, corrections (repairs and shortages), and redundant processing [5-6]. The most frequently used Lean Manufacturing tools that help reduce waste include: 5S, TPM, POKA-YOKE, KANBAN VSM and Kaizen.

The article analyzes the impact of selected Lean Manufacturing tools on the number and duration of failures. They were carried out in one of the metal industry production plants producing welded pipes in accordance with the requirements of harmonized standards.

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LEAN MANUFACTURING TOOL FOR MAINTENANCE – TPM

One of the basic Lean Manufacturing tools used for maintenance management is Total Productive Maintenance. Total Productive Maintenance (TPM) is a concept of productive maintenance by eliminating failures, designed to achieve comprehensive efficiency of the production system as a result of the involvement of all people in the organization [7]. The Lean Manufacturing tool, TPM, is based on eight pillars aimed at maximizing the efficiency of the manufacturing process while minimizing failures of production machines and devices [9]. The implementation of a properly functioning TPM tool allows you to create an operating environment for machines and devices in such a way as to minimize waste caused by machine failures.

The fact of proper implementation of TPM tools directly affects the achievement of much more favorable values of indicators used to control the level of maintenance, such as MTTR (Mean Time to Repair) and MTTF (Mean Time to Failure) than before the implementation of TPM.

RESEARCH METHODOLOGY

An analysis of the impact of the use of the TPM tool on the number of failures and the duration of failures was carried out in one of the metal industry production plants producing welded pipes in accordance with the requirements of the standard. Due to the type of production and mass production, the entire production process was automated. The production line consisted of the part responsible for taking the input material, forming

the product, welding using an automated welding robot, and non-destructive testing. The production line and equipment used to carry out individual operations within the production process were regularly inspected once every four months. Due to the large number of breakdowns and machine stoppages, a decision was made to introduce comprehensive TPM implementation activities. As part of the implementation of TPM in the production plant, the following were introduced: creation of a schedule for preventive inspections of machines and devices, creation of a database of reported failures along with an analysis of the duration of their repair, implementation of devices analyzing changes in process parameters, comprehensive training of employees from the maintenance department.

The TPM tool implementation process took 4 months. The measurement of the analysed parameters, which included: failure duration, number of failures and machine available time, was carried out for a total of 12 months and included the time before the introduction of the TPM tool (6 months) and after the implementation of TPM (6 months).

First, data on the failure time of the production line for the production of welded pipes was analysed before the implementation of the TPM tool. Statistical analysis was then performed to determine the statistical significance of the observed differences in failure times before and after the implementation of TPM tools. The last stage of the analysis was to determine the following indicators: MTTR (Mean time to repair) and MTTF (Mean time to failure) and compare them before and after TPM implementation.

$$MTTR = \frac{\sum_{i=1}^{N} T_i}{N} \quad (1)$$

$$MTTF = \frac{T_D - \sum_{i=1}^{N} T_i}{N+1} \quad (2)$$

Where:

T_i – failure time,
N – number of failures,
T_D – available time of machines or groups of machines.

RESULTS AND DISCUSSION

As a result of the analysis of the production process carried out in the period of 6 months before the implementation of TPM and 6 months after the implementation of TPM, information regarding the verification time was obtained, Table 1.

Over a 6-month analysis of the average monthly failure time before and after the introduction of the TPM tool, a decrease in the failure duration of approximately 58 % was found. In order to determine the statistical significance of differences between the times of failures before and after the implementation of the TPM tool, the Mann Withney U test was performed, where

Table 1 **Machines failure time**

	Without TPM	With TPM
average failure time / h	41,5	17,5
Median / h	42	18
MAX failure time / h	51	21
MIN failure time / h	29	14

the assumed confidence level α for each of the analyzes was 0,05.

As a result of the study, it was found that there are significant statistical differences in the duration of failure compared to the state before the implementation of TPM (p>a). The results obtained in the analyzed case indicate a significant reduction in the duration of the failure, thus confirming the effectiveness of the implemented TPM tool.

The last stage of the analysis carried out in the article was the determination of MTTR and MTTF indicators before and after the implementation of the TPM tool (Figure 1 and 2).

The analysis shows that the average value of the MTTR indicator before TPM implementation was 2,2 hours, while after implementation it was only 1,75 hours. In the case of the MTTF indicator, the difference between the length of time between subsequent failures after TPM implementation increased by more than 35 hours. The obtained results indicate improved effective-

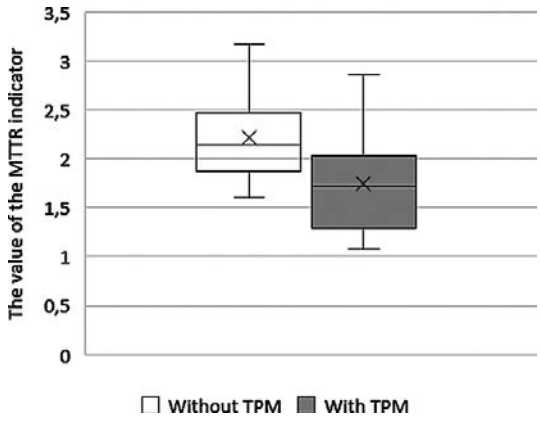

Figure 1 The value of the MTTR indicator before and after TPM implementation

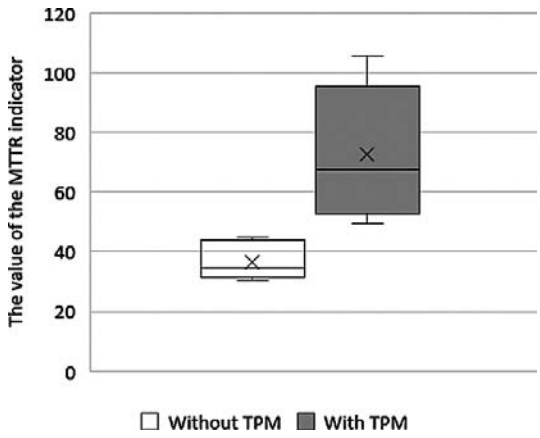

Figure 2 The value of the MTTF indicator before and after TPM implementation

ness in terms of reducing the repair time of occurring failures and reducing the number of stops that cause failures.

SUMMARY

One of the most important factors enabling increased competitiveness is the creation of such technical and organizational solutions that allow for the elimination or reduction of waste. The concept of Lean Manufacturing and its tools, such as TPM, allows to improve the way of organization of the production by implementing various types of improvements and standardized activities in the field of manufacturing processes.

This article presents results showing the impact of the TPM tool on the number of failures and the duration of failures in one of the metal industry production plants producing welded pipes in accordance with the requirements of the standard. Based on the results obtained, it was found that there are statistically significant differences in the duration of failure compared to the state before the implementation of TPM (p>a). The analysis of the MTTR and MTTF indicators indicated an improvement in effectiveness in terms of reducing the repair time of occurring failures and reducing the number of stops causing failures. Therefore, it can be concluded that changes resulting from the implementation of LM tools in the production plant significantly influenced the parameters of the production process, which was confirmed by scientific methods.

The data on the basis of which the analysis was carried out come from one production plant (case study), which does not allow defining an unambiguous rule describing the impact of LM tools on production processes. The obtained results, however, allow to confirm the as-sumptions of the legitimacy of the implementation of selected LM tools for individual parameters of the manufacturing process.

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Note: Szymon Pawlak is responsible for English language, Katowice, Poland