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USE OF LEAN MANUFACTURING TOOLS IN PRODUCTION LOGISTICS

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Abstract. This paper presents a concept of using selected lean manufacturing methods. The lean manufacturing methods and techniques allow a systematic identification and elimination of waste by the continuous improvement of logistics processes in manufacturing enterprises. The reduction of costs and improvement in product quality, and also customizing a product with a customer's requirements in mind, have a key importance in gaining competitive advantage. This is often connected with the maintenance of machines, particularly to increasing their reliability and obtaining better production flexibility. Those objectives can be accomplished by using lean manufacturing methods.

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1. INTRODUCTION

In contemporary reality, it is only enterprises in which manufacturing processes, or to put things more broadly, the business ones, are skillfully organized, can meet the challenges of the market and compete with the rivals. That is the reason why there is a lot of interest in the implementation of controlling methods being in accordance with the concept of lean manufacturing for the part of the owners and the management boards of enterprises (Marciszewska, 2009, p. 73). The correct implementation of lean techniques and tools provides the possibility of producing ever more requiring ever less of human effort, devices, time and space, while simultaneously reducing the distance to accomplish the objective which is constituted by providing customers with the appropriate merchandise, at the appropriate time and at the lowest acceptable costs. The concept of Lean Manufacturing makes it possible to effectively implement 'lean' manufacturing in each and every domain of the activity of an enterprises.

2. TPM – THE FUNDAMENTAL LEAN MANUFACTURING METHOD

The abbreviation 'TPM' can be extended as 'Total Productive Maintenance' (Kubik, 2012, p. 3), and that means productive machine maintenance. A major quality of TPM is the introduction of the autonomous maintenance of devices and machines by operators, and that means the integration of numerous fundamental operating activities with manufacturing process (Legutko, 2009, p. 12). The most important objective of TPM is to accomplish the level of three zeros: zero breakdowns, zero defects, and also zero accidents at work (Walczak, 2012, p. 412).

Even though TPM originates from Japan, nevertheless, the first systemic activities the objective of which was to streamline the functioning of a machine park date back to the beginning of the twentieth century, and they were undertaken in the United States. At the beginning of the twentieth century, machines were becoming more and more complicated, therefore, the Americans separated a dedicated department of an enterprise responsible for removing breakdowns, and also for performing maintenance work and providing preventive maintenance.

After the Second World War, this methodology arrived in Japan as part of assistance in rebuilding the destroyed industry. The Japanese perfected the concept of the existence of a separate flow maintenance department, and made all employees involved in looking after machines (productive maintenance). For the first time ever, the name 'TPM' was applied and defined by Japan Institute of Plant Engineers in 1971 (Furman, 2014, p. 248). The term 'TPM' was as well complemented by the addition of Corrective Maintenance, and that means continuous improvement in the construction of machines, resulting from the imperfect design of them.

The development of the techniques of controlling the condition of a device (for instance, by means of the analysis of vibrations, infrared photography, or the analysis of the chemical constitution of an oil etc.) contributed to developing, in the 1980s, the concept of Predictive Maintenance, and that means discovering and the elimination of problems before they bring about the unplanned standstill of a machine (Jasiulewicz-Kaczmarek, 2005, p. 127).

TPM is the organizational method consisting in managing a machine park in a way making it possible to minimize the costs connected with the stoppage of a line brought about by the breakdowns of devices. The implementation of TPM is based upon the presumption of making personnel from the flow maintenance department involved in manufacturing process, but also upon that of increasing the responsibility of the operators of machines for maintaining the perfect condition of a machine park. The crucial element is the participation of operators in the programme of streamlining, and also in predicting and the prevention of the breakdowns of them. The collaboration between employees responsible for continuous flow maintenance and operators in the course of maintenance work and repairs makes it possible to become mutually acquainted with one another, and to accomplish the improvement of the skills of operators, which finds its reflection in becoming better acquainted with a device. TPM is based upon preventive predicting, and upon the prevention of the occurrence of defects in the course of the functioning of machines, thanks to which it becomes possible to extend overhaul lives, to reduce the number of the cases of machines being non-operational and breakdowns, and also the time of removing the latter ones, as well as accomplish the better management of replaceable parts (Świątoniowski, Gregorczyk & Rabiasz, 2011, p. 469).

Another important difference between TPM and traditional flow maintenance is an approach to the inspections of, and maintenance work on, machines. TPM presumes the most important role of broadly-understood prevention, be it in the meaning of inspections, or in that of maintenance work, rather than that of the production plan. In accordance with the TPM method, the time devoted to modifications and maintenance work bears fruit in the further course, when a machine still remains ready to be used in manufacturing. Fulfilling this objective is possible thanks to using such tools as preventive maintenance (the prevention of breakdowns), modification maintenance (the modification of equipment in order to prevent breakdowns and facilitate maintenance), the prevention of maintenance (designing, and also installing, reliable equipment which requires limited maintenance), and also breakdown maintenance (repairs).

In order to meet the pre-formulated objectives, it is indispensable to take actions in eight crucial areas (Kubik, 2012, p. 15):

1. focused improvement;
2. autonomous maintenance;
3. planned inspections performed by operating personnel and flow maintenance employees;

4. technical training within the scope of operating and machine maintenance (for operators);
5. a programme of early equipment management;
6. quality maintenance;
7. office TPM;
8. managing safety and the environment.

TPM identifies the six big losses (in three sub-groups) (Michlowicz, 2010, p. 42):

Time losses (availability):

1. time losses resulting from breakdowns;
2. time losses in connection with the conversion and the adjustment of equipment.

Losses of effectiveness:

3. losses brought about by idleness and short-time downtimes;
4. performance losses brought about by limiting the speed of machines.

Losses resulting from faults (quality):

5. losses connected with defects and improvements;
6. losses connected with starting equipment up.

3. SETTINGS

The TPM theory is built upon the seven fundamental pillars (Nakajima, 1988).

1. Pillar 1 – autonomous maintenance.

Autonomous maintenance is the group of activities the objective of which is to include operators in the maintenance of machines operated by them, independently from the maintenance department (Kubik, 2012, p. 63).

Autonomous maintenance includes:

- cleaning and inspection – removing impurities, finding problems out and solving them,
- eliminating the sources of problems and confined spaces – removing the sources of impurities, and also improvement in access to all the parts of a machine facilitating cleaning and lubrication, ipso facto, shortening the time of cleaning,
- determining the standards of cleaning and lubrication – developing the standards guaranteeing effective cleaning and lubrication, and also drawing up the schedule of work and periodical inspections,
- conducting the general inspection of a machine – training upon the basis of the manual of a machine, and also conducting the general inspection of a device in order to discover irregularities, and to remove them,
- conducting the autonomous inspection of a machine – preparing the standard checklists,

- introducing the visual management of machine maintenance – standardizing and visual management of all activities connected with machine maintenance,
- introducing constant autonomous management – developing the principles of collecting data on the breakdown times, and the analysis of the obtained data for the purpose of improvement equipment.

2. Pillar 2 – Kobetsu Kaizen

It consists in constant improvement in the process of the small steps method. The main presumption of the Kaizen philosophy is that of incessantly raising standards by means of the correct identification of needs through identifying a problem. In order to discover the source of a problem, the following TPM tools are used: PDCA, 5Why, FMEA, the Ishikawa diagram or the Pareto chart.

3. Pillar 3 – planned machine maintenance

The crucial aspect of planned machine maintenance is conducting planned, preventive activities in order to avoid breakdown-related machine downtimes. The scope of those activities includes: the analysis of defects, and also of preventive measures, managing lubrication, managing the preventive replacement of worn-out sub-assemblies, managing appropriate adjustment, managing replaceable parts and the costs of maintenance, and also shortening the time of repair.

4. Pillar 4 – quality maintenance

It consists in developing a number of quality tools, the objective of which is to verify and to improve the current quality of a product. In order to accomplish that objective, the technical analysis of those places on the processing line which are responsible for the occurrence of potential errors influencing the final form of a product is performed.

5. Pillar 5 – office TPM

This is the set of methods applied for the identification and elimination of losses influencing the performance, quality, and also the costs, of office work. It includes activities the intended result of which is the improvement of office processes concerning information circulation and processing, and also developing it, accompanied by processing materials, and that means the products of office work.

6. Pillar 6 – safety, health and environment

In order to follow the principles of Pillar 6, it is indispensable to take actions consisting in eliminating hazards to employees, and also to the environment, by means of reducing the use of materials, and also of energy, and that means, in other words, by means of the elimination of waste.

7. Pillar 7 – training

To follow the principles stipulated in the above-mentioned pillars, it is indispensable to conduct training in order to raise the level of the technical abilities of personnel, as well as that of improvement within the scope of problem-solving techniques. A significant aspect of training is the introduction of teamwork learning methods, and also those of improvement in communication skills.

The implementation of TPM may be described as proceeding in three phases:

Phase 1 – the education of the entire personnel, commencing with the management board, with line employees being the last ones to be educated.

Phase 2 – the development of a system based upon teamwork, and also undertaking preparatory activities for the introduction of the 5S method.

Phase 3 – the implementation of the TPM tools by means of undertaking subsequent activities in an enterprise commencing with announcing the intention to implement the new system. This step needs to include placing emphasis upon the significance of TPM for the development of a company, and determining it being indispensable to identify current conditions dominant in a manufacturing enterprise by means of the measurements of the breakdown frequency of machines, the level of quality, the duration of time needed for conversion, and also the assessment of the involvement of the personnel. In the further course, it is needed to determine a so-called pilot area, in which the 5S method will be introduced. When the results are visible and satisfactory, it is possible to proceed directly to initiating the TPM programme, and to extending it onto the remaining departments and branches of the company.

An important role in the TPM method is that played by the analysis of losses (Michlowicz, 2012, p. 136). For the purpose of conducting a loss analysis, it is most frequently three indicators that are applied (Mączyński & Nahirny, 2012, p. 210):

1. MTTR (Mean Time to Repair).
2. MTBF (Mean Time Between Failures).
3. OEE (Overall Equipment Effectiveness).

This indicator show what per cent of theoretically obtainable effectiveness is that of a device or line being investigated. Most frequently, it is calculated with the use of the following simple formula (Michlowicz, 2012, p. 136; Palonek, 2013, p. 27):

OEE coefficient = availability * performance * quality * 100%

and that means:

OEE = A*P*Q*100%

where:

A – Availability: practical availability, the coefficient of availability – working time (available time – standstills) / net run time (available time);

P – Performance: the effectiveness of performance, performance coefficient – actual manufacturing / target manufacturing;

Q – Quality: the coefficient of quality – good manufacturing (number of good pieces) / actual manufacturing.

4. IMPLEMENTATION OF LEAN MANUFACTURING TOOLS AND TECHNIQUES IN AN ENTERPRISE

The implementation of lean manufacturing methods in the enterprise being analysed was commenced in the year 2001 with training the managerial personnel. The training was being conducted in the enterprises being parts of a corporation from the automotive industry. In the further course, they were commenced in the enterprise, and extended in order to include all employees. The training made it possible to make the employees acquainted with the lean method, and also to make them acquainted with the tasks and objectives which they would strive to complete and accomplish. The plan of the implementation of particular tools and techniques was presented, and, in the further course, team responsible for the implementation of selected lean methods and techniques in particular departments were formed. Each and every of those teams had an external coordinator, and also a leader, who was the employee of the enterprise.

A pilot manufacturing area and the work station which was bringing about most problems to operators, were selected. It was revealed to be indispensable to:

- select the items situated within the selected area (unnecessary cabinets, tooling, and also equipment of machines, were eliminated by means of the use of 'red cards' – the area of 'red cards' was also organized);
- the places of standstills of trolley trucks, and also pre-picking areas, were marked;
- the standard of describing machines and the markings of them was developed;
- the FIFO queues on in-racks were introduced;
- the transit roads were introduced.

The machine selected for the needs of the pilot programme was subjected to throughout cleaning by the members of the team. The fact that, apart from the employees of the area and the operators of the machine, the team was composed of is flow maintenance employees is worth emphasizing. In the course of cleaning up, all and any sources of impurities were identified, and so were places access to which for the purposes of cleaning up and controlling was more difficult. The revealed problems were recorded, and the activities to be performed to eliminate those problems were determined. The individuals responsible for conducting them were selected, and the time of completing the task was determined precisely. After removing the noticed incompatibilities, a standard of cleaning up the device was developed. A 'checklist' was drawn up. The checklist was developed in the form of the tabular presentation of the separate areas requiring to be checked. The separate checkpoints were numbered, and appropriate numbers were placed directly on the machine. In addition to that, on the reverse of the list there is a diagram of the device accompanied by all the checkpoints.

The employees of the flow maintenance department drew up the schedule of maintenance work containing the tasks which are to be completed by the operators of the device accompanied by deadline for completing them. Periodical maintenance work, accompanied by removing breakdowns, is performed by the employees of the flow maintenance department, accompanied by the operators.

At the work station, a quality improvement programme was introduced. In it, the operators were obligated to collect data on the subject of downtimes of a device. Applying the Pareto chart, the most significant causes of the standstill of a machine are determined. Using the Ishikawa diagram, and also of the 5 Why? analysis, by means of brainstorming the method of eliminating them is determined. Also, the fault tree analysis is performed for the products not meeting the qualitative requirements. The fault tree analysis shows connections and logical hierarchy between numerous conditions or the potential causes of the occurrence of faults.

The TPM Table for the pilot work station is presented in Figure 1.

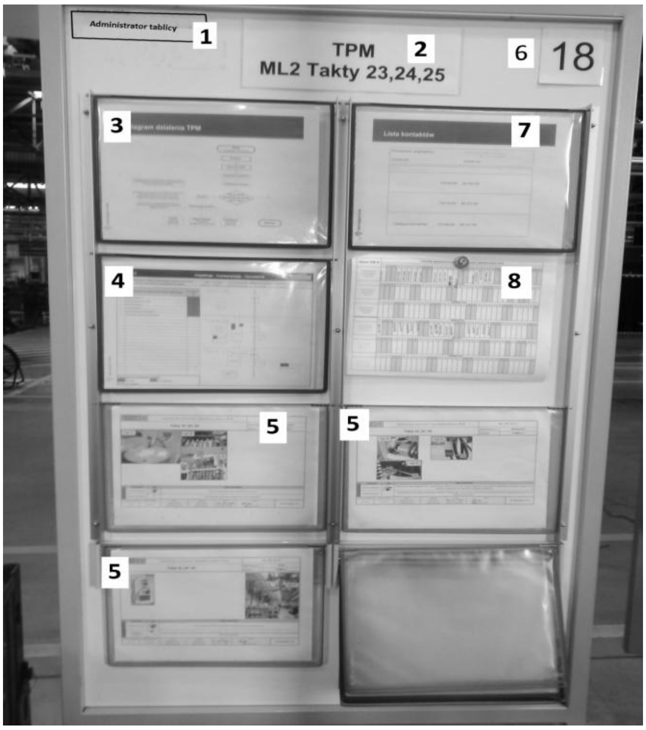

Fig. 1. TPM Table: 1) Surname of the employee of the flow maintenance department responsible for the pilot area; 2) scope of the area to which the table refers; 3) information about the course of action in the case of a breakdown; 4) plan of Inspections, Maintenance and Cleaning; 5) Operator's Activities Supervision Card; 6) no. of the work station; 7) list of contacts; 8) control form

5. CONCLUSIONS

In this paper, the selected lean manufacturing techniques and methods implemented in a manufacturing enterprise are presented. The concept of lean manufacturing makes it possible to eliminate losses in manufacturing process. Marking transit roads in the production room increases the safety of the personnel, and streamlines transportation processes. Eliminating unnecessary tools, or tooling, from the work station makes it possible to conduct manufacturing processes more effectively. The greatest asset of the use of lean is changing the approach of the operators to the machine. Making the operators involved in daily servicing of the device makes it possible for them to become better acquainted with their work station. Broadening their competences within the scope of technical maintenance brings about increase in the reliability of devices. An active participation in removing breakdowns, or in the analysis of the occurrence of defects, raises the qualifications of the operators. The additional asset of the implementation of lean tools is reducing the workload of the employees of the flow maintenance department. The high qualifications of the personnel of the flow maintenance department may be used for the purpose of the modernization of devices, or for that of removing major breakdowns.

The correct implementation of lean manufacturing means enormous benefits for an enterprise. However, it ought to be remembered that, without making all employees involved, even the best method will fail to bring the expected results.

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BIOGRAPHICAL NOTES

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