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IMPROVING BUSINESS MAINTENANCE PROCESSES USING LEAN MANUFACTURING TOOLS – CASE STUDY

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Objective: The aim of this article is to analyze and evaluate the introduction of selected Lean Manufacturing tools into the management of a given enterprise, the task of which is to increase the efficiency of the machine park and improve the quality of finished products. The introduced changes are also expected to increase the detectability of waste, avoid unnecessary stopping of machines and unplanned stoppages.
Design/methodology/approach: As part of the research, the internal materials of the surveyed company were analyzed and free interviews with employees and specialists of the plant were conducted. An efficiency analysis of the production process was carried out.
Findings: In order for the improvement of technical progress to function well, the requirement of an appropriate technical condition and the course of technical progress. The entire process flow of the product should be analyzed.
Research limitations/implications: Subjectivity of the analysis thanks to the use of a qualitative approach in research. Future research may be related to creating a mentoring program in the area of interest.
Practical implications: The results of the study can be used as input data for the design of training programs in the study area.
Social implications: The concept of lean manufacturing is a tool for constant changes that can be observed both in the modern economy and in society. They require dynamic flexibility from entrepreneurs and looking for solutions that can optimize production processes. The concept includes a slogan such as corporate social responsibility, which grew out of sustainable development. It is prioritized by managers of various companies. Therefore, this work deals with the subject of Lean Management as an instrument of responsible business.
Originality/value: This article is addressed mainly to companies that want to implement and improve Lean Manufacturing tools. It shows how companies can improve selected areas of production.

Keywords: logistics, machine park, lean manufacturing, continuous improvement.

1. Introduction

The development differentiation of Polish voivodships can be seen on many levels, including economic, infrastructural, economic, social or human capital, this in turn is reflected in the level of their competitiveness and innovation. The national strategy of regional development indicates that the aim of the state's regional policy should be to increase the competitiveness of regions (especially in the international arena) with simultaneous activities aimed at equalizing development opportunities, and thus aid for less developing regions (Krajowa Strategia Rozwoju Regionalnego 2010-2020). Building, and thus maintaining a competitive and innovative voivodeship is a complex and long-term process.

In the era of strong competition on the market of production and service enterprises, constant improvements of production processes aimed at increasing efficiency and obtaining better economic results is an important element of both their development and the entire region. Enterprises that want to remain competitive must constantly increase their production potential by looking for ways to improve production.

Companies are forced to look for available opportunities to increase the efficiency of the entire enterprise, and in particular taking into account the production processes, so that their efficiency is as high as possible. Each change should be monitored, which allows for a constant search for improvements that increase efficiency and the elimination of waste areas and cost reductions (Anh Nguyen Xuan, 2016).

The Lean concept, used to improve efficiency and effectiveness, provides tools in this respect, i.e. Total Productivity Maintenance (TPM). The pillar of TPM is the belief that it is possible to optimize production processes in a non-investment manner, and the period of operation of machines and devices can be adequately extended by introducing selected solutions in the functioning of maintenance services and the approach to maintenance activities among operators. Therefore, it is not necessary to invest in newer and newer technologies, the payback period of which is sometimes longer than the operational usefulness of the device (Kruczek et al., 2009).

This article aims to analyze and evaluate the use of selected Lean Manufacturing tools in a selected enterprise, which are to enable, above all, an increase in the efficiency of the tested production plant.

2. Lean Manufacturing

The need for improvement has been known in organizations for a long time. Now it has become a requirement and is gaining more and more importance. Internal improvement characterizes enterprises that want to be flexible, quickly adapt to turbulent surroundings and, above all, effective. In production management, there is also a process approach to the organization of production, because in this way it is easier to observe when and how the added value for the customer is created in the manufactured products. All activities improving the process and its better layout allow for more satisfactory economic effects (increase in efficiency, cost reduction, improvement of quality issues), but most of all, the level of customer satisfaction increases (Bhamu, Sangwan, 2014). Improving production is a complex process that can be continuous and slow, as improvement actions can be adapted to the process in small steps. On the other hand, improvement can be implemented on the basis of innovations that, of a radical nature, can lead to breakthroughs in production (Trenkner, 2016).

The positive effects of production improvement can also be seen in the reduction of many disruptions during the implementation of processes. These can appear anywhere, because apart from the main production, disturbances are also found in supporting and controlling processes. Each of these types of processes can be affected by two types of disturbance (Wiśniewski, 2010):

- special – more unfavorable from the quality perspective, as they can significantly affect the properties of a given process and the product itself. They can appear suddenly, but they can also be intensifying and systematic disturbances. If they can be quickly identified with the source, it is relatively easy to remove them completely (example: machine failure, operator error);
- random – usually occurring in large numbers, with a lower degree of interference in the process, although it may lead to its variability. It is necessary to identify them as well as the cause, source of origin, in order to prevent the reduction of their impact, because in theory they are already inscribed in the nature of the process, and their complete elimination is practically impossible (example: a design defect of the material).

By introducing specific improvements and changing the organization of the process, the enterprise is therefore able to limit the impact or fully eliminate many disruptive factors, and also quickly correct the functioning of the process. Thanks to this, financial losses that could possibly be generated can be prevented.

One of the most effective, popular around the world and gaining more and more popularity concept of improving production enterprises is the Lean concept, and in relation to manufacturing processes – Lean Manufacturing (Thurston, Ulmer, 2016).

Lean Manufacturing is a view that has its origin in the Toyota Production System, which dates back to the 1970s and 1980s (Ĉiarnienė, Vienažindienė, 2012). The leading goal in it is to eliminate waste, which is nothing other than losses for the company (Yamada, 1972). Eliminating losses is considered to be the most effective way to increase the profitability of the enterprise. It is important here to know what exactly is a loss and at what point it is created. In this way, there is a great chance to combat the so-called bottlenecks in the production process throttling and inhibiting the possibility of greater efficiency (Bicheno, 2008). At this point, it is worth presenting the types of waste, taking into account the 3 factors (man, machine, material) that are defined by the Lean Manufacturing concept (Czerska, 2014):

- excessive traffic,
- waiting,
- overproduction,
- overprocessing,
- defects and errors,
- warehousing,
- excessive transportation.

The main value of Lean Manufacturing is the orientation on the constant pursuit focused on the growth of the defined added value for the customer, which is an indication of the direction in which the improvements should go, while the consumed resources and times of product production cycles will be reduced by eliminating the above-mentioned waste ("doing more with less") (Thurston, Ulmer, 2016).

The leading method of Lean Manufacturing is KAIZEN, the idea of which is to constantly improve and improve systems, involving all employees, regardless of their function in the company. In the use of work and workshop, it has the task of leading the progress and technological progress (Gabryelewicz et al., 2015).

One of the core Lean Manufacturing tools is 5S, which has methods to increase workplace safety and increase productivity. The interpretation of the TPM functions is due to 5 that they meet the legalization and legalization of the impacts on productivity and merfet and technology technology, so as not to reap the benefits. It also teaches the discipline necessary to exercise workers as workers (Imai, 2006).

3. Company analysis and research results

The research covered company X, which specializes in the production of plastic cards. It is a company that offers various cards that can be used as discount, gift, loyalty or ID cards. They are largely used in the commercial industry. The company provides products and services to many countries around the world. It is the industry leader in the voivodeship. The company

also offers cards with a paper base, which are an environmentally friendly solution. The following plastics are used for production: PVC, PS (Polystyrene) and PET-G.

The technological process of cards begins with the preparation and delivery to the printer by graphic designers of graphic files that are needed to start a given order. At each station, the necessary materials needed for production should be prepared. For printing the cards, offset printing, digital printing or screen printing are used. The color palette is used for reproduction CMYK (a set of four basic colors: cyan, magenta, yellow and black). Screen printing is used as an auxiliary technique, most often it is used to apply a base, signature panels or UV varnish. The next stage is folding the sheets. The sheets are merged using dedicated machines. It is done by machine picking the materials in the correct order – foil, card back, card face and foil. The prepared sheets are ready for the next stage – lamination.

The main goal of the study is to analyze and assess how the selected Lean Manufacturing tools will improve the manufacturing process. First of all, it enables an increase in the efficiency of the tested production plant.

The introduction of appropriate Lean Manufacturing tools allows us to achieve satisfactory efficiency and quality of manufactured products. The main pillar is implementing the philosophy of continuous self-improvement in employees.

The work includes an analysis of theoretical issues, own observations and an analysis of internal materials of the examined enterprise, as well as free interviews with employees and specialists of the enterprise.

Two research sources were used for the analysis. The first of these are primary sources that result from the analysis of performance data. They also include: a description of the technological process and the introduced Lean Manufacturing tools (derived from own observations) as well as data obtained through free interviews with employees of the company.

The second is secondary sources. They are based on materials provided by the company, including: performance reports, training materials on the implemented 5S tool as well as requirements and standards for the production of cards.

In this article, the company that has implemented 5S management has been observed. Work is still underway to maintain order and discipline at the workplace. The main assumption of introducing the 5S method was to create a work environment that improves quality, reduces waste and increases efficiency. It greatly influences employees by increasing responsibility for tools, activities and processes related to their workplace. 5S is conducive to continuous improvement, both of employees and processes, which affects efficiency.

The person introducing 5S is designed to train employees, show in a simple way that maintaining cleanliness and order and equipping your workstation with the tools necessary for work significantly contributes to increasing the efficiency and comfort of work. The person designated to introduce 5S is obliged to provide and show the employee examples of practical solutions.

The inspected plant gradually introduced changes. Initially, he designated the areas in which the 5S method would be implemented one after another. The main selection criterion was in which part of the enterprise it is most needed to carry out a cleanup action.

In the case of this company, it was a production hall. The first steps that were introduced were to organize the production, to designate places marked with different colors. This was to make employees aware of where to put good products, where bad, with quality defects, and where products that are ready for the next stages of production. In this case, color markings were used. There are designated areas for finished products marked with green tape, for bad ones – red. On the other hand, when it comes to completing one stage of production, the end operator puts a piece of paper with the machine written on the pallet, which is the next in the queue of order execution. There are also designated places for pallets next to each machine, so that everyone knows how to put a pallet and that there is no situation where they will interfere with the work of the operator of a given machine. When it comes to forklifts, there are also designated places to shorten the time of searching for them all over the hall by an employee. They are set up so that each operator has easy access to them.

In addition, each workstation has been tidied up and equipped with the tools necessary to perform work on a given machine. There were also special places for each operator to put them back so as to avoid situations where his substitute, when starting work, did not have an adequately equipped station with the necessary tools.

Information on problems is collected on an ongoing basis from the entire production department. The 5S leader works on delivering solutions and engages employees in process improvement. This is to streamline and optimize production and the employees involved are rewarded for submitting ideas.

For the company, personnel training is a priority. The premise of the plant is the conviction that only well-trained personnel are able to work efficiently and perform the necessary maintenance. In order to verify the correctness of the implemented solutions in the enterprise, an internal 5S audit is carried out once a month. It consists in assessing the strengths of the company that work properly and which can be improved. Supervision has a motivating effect on employees because the committed team is rewarded.

Examples of the productivity of: production machines, machines from the personalization department and employee productivity are discussed below.

Company X has specific capacities for each machine. Starting with the production machines (see table 1).

Table 1.
Efficieny of sample bodies

Process/machine name	Description	Efficiency per hour
Komo	Obverse print	70000
Komo	Reverse print	70000
Svecia	Varnish printing	15000
Svecia	Panel printing, color	13000
Kolator	Merge sheets	15000
Laminator	Sheet lamination	11000
Punch A	Cutting a card with a key	7000
Punch B	Cutting out	11000
AVI	Automatic control	7000
KURZ-2000	Overlaying a hologram	1900
MM-7000	Applying a magnetic strip	2900
Packing	Packing	18000

Source: own study based on data from the examined enterprise.

As shown in Table 1, each machine in production has a specific capacity per hour. For each shift, managers prepare a schedule for employees with a specified machine and describe in detail how much time the operator can spend on the device and calculate what standard should be performed adequately to the rest of the working time.

Machine operators have been trained for 5S in order to best adapt their work stations. Every tool has its place. The next step in the training of machine setters is to provide knowledge on how to maximize the available time of the machine for production. The maintenance department and the production department, with appropriate cooperation, allow to improve the efficiency of even the most worn-out machine park and reduce the risk of such threats as breakdowns or unplanned stops.

Another department of the surveyed company analyzed was personalization, which is also equipped with a machine park. There are much fewer machines in this section than in production, but the number of functions in which we can personalize the card is very extensive. As a result, the functionality of these machines is very high.

The personalization department is managed in a similar way to the production department. The employees were also trained in the 5S method and the workplace at the machines is adequately equipped with the necessary tools. The higher aspect in the personalization department at the beginning of the training of machine operators was the transfer of knowledge on the elimination of minor failures and the observation of parts that wear out on the machine. Thanks to this, the operator can transfer the required parts to the maintenance worker in advance, so that he can place the order and schedule the replacement in the near future.

Table 2.
Weekly breakdown by shift

Changes	DEPARTMENT	Working time [h]	Instrument time [h]	Objective [pcs]	Execution [pcs]	Efficiency [%]	Productivity [%]
Change I	BODIES	3 089,5	461,6	24 070020	21 432 860	78,23%	51,82%
	PERSONALIZATION	8 031,5	175,5	11 349465	9 306 415	66,93%	55,20%
Change II	BODIES	2 713,5	428,7	21 292770	17 985 263	72,11%	46,49%
	PERSONALIZATION	5 534,5	94,0	7 779575	5 899 818	64,12%	59,89%

Source: own study based on data from the examined enterprise.

Table 2 describes the time of work and the goal to be performed and what has been done, thanks to which it is possible to calculate losses or profits. From the table above, it can be concluded that the higher efficiencies on the bodies are estimated to be around 80%, while the larger losses and lower personalization efficiencies on a weekly basis are only around 50%. It follows that the introduction of selected Lean Manufacturing tools was more successful in the production department. When it comes to the personalization department, by talking to the operators and employees of the department, come to the source of the problem together. Using the Kaizen method, the idea of which is to constantly improve and streamline processes, involving all employees, regardless of their position in the company.

The implemented selected Lean Manufacturing methods contributed to the achievement of efficiency at the level of 80% up (Table 3). This allows you to estimate what number of finished products the operator is able to produce during one shift. It is a great help for department managers in defining the time necessary to perform a given order and estimating when the order will be ready so that the logistics department can order transport. Before the implementation of the changes, there were crises due to which the delivery had to be postponed at the last minute, which was associated with costs.

Table 3.
Weekly employee performance breakdown

	Working time [h]	Instrument time [h]	Objective [pcs]	Execution [pcs]	Efficiency [%]	Productivity [%]
Worker 1	99,0	0,0	207 500	179 155	81,08%	81,08%
Worker 2	460,0	4,0	5 946 585	5 729 877	93,61%	47,43%
Worker 3	288,0	89,0	2 590 580	3 129 800	105,52%	38,89%
Worker 4	465,0	21,0	4 275 500	3 935 986	86,44%	82,54%
Worker 5	248,0	13,3	1 027 875	978 116	82,16%	77,77%
Worker 6	401,0	55,4	3 497 375	3 429 725	82,59%	42,93%
Worker 7	361,0	36,5	2 146 000	2 222 995	86,37%	77,64%
Worker 8	347,0	33,0	1 836 000	1 958 613	80,36%	72,72%
Worker 9	390,5	111,1	4 002 700	4 134 400	102,78%	40,50%
Worker 10	48,0	0,0	504 000	488 940	89,45%	89,45%

Source: own study based on data from the examined enterprise.

An improvement that influenced the quality of manufactured products and minimized the waste of material was the organization of workstations and equipping them with the necessary tools. The reduction of errors during the production process resulted in the production of smaller additives. From the 8% allowance for a given job, it was reduced to 3%, which contributed to a reduction in production costs.

An internal suggestion program called. By filling in the sheet available in boxes located in each of the production areas of the plant, employees can submit their ideas to improve the production organization system to make it more efficient, or with improved ergonomic conditions in the work area. For the implemented suggestions, a reward system has been established, consisting in the fact that once a month an elected committee meets, which rewards the ideas collected from the month and selects 3 of them that gave the greatest effect in terms of efficiency or ergonomics. And the solutions that will be used are rewarded in the form of a director's bonus added to the basic salary. This gives you even more motivation to share each idea and come up with newer and newer improvements.

Recommendations for further improvement are the introduction of a preventive maintenance procedure, which involves the operators taking care and monitoring of the condition of the machines. The goal is to introduce a routine where employees are required to record each fault, taking into account what exactly failed and what was the repair time. Such information is useful for planning the order and allows you to accurately estimate the time of execution of a given order. In addition, these measures should affect the efficiency and stabilize the quality of production.

In order to increase the efficiency of the personalization department, it will be helpful to analyze the process of repeated orders and create a diagram, thanks to which operators will be able to tune machines faster and more efficiently. The purpose of the solution will be to create a pattern for regularly repeated orders, thanks to which the machine setup time will be minimized. The idea of improvement is to increase the efficiency in a given department, and shortening the machine changeover time makes it possible.

4. Summary

The aim of this article was to analyze and evaluate the introduction of selected Lean Manufacturing tools into the management of a given enterprise, the task of which is to increase the efficiency of the machine park and improve the quality of finished products. The discussed changes increased the detectability of waste, avoided unnecessary stopping of machines and unplanned stoppages. Reducing the number of device failures increases their availability, and thus the efficiency of production departments.

The analysis of the data collected above allows to determine the effectiveness of the implementation of the principles and tools of the Lean Manufacturing concept in the surveyed company. This allows you to see results in terms of increasing efficiency and striving for further improvement.

In order for the improvement of processes to be effective and function well, it requires appropriate recognition of the situation of the examined company and the course of the production process. The entire course of the product process should be analyzed, taking into account each stand separately. This will allow you to capture waste and react quickly to eliminate it. Thanks to the analysis of the process, it is possible to spot the most troublesome stages of production and with the involvement of each employee, both managers and machine operators, it is possible to find a solution to the problem easily and quickly by introducing appropriate improvements.

Research conducted at the Poznań University of Technology shows that the 5S and Kaizen methods are the most common solutions implemented in enterprises among Lean tools. This is due to the flexibility of their application. Referring to these studies, it has been shown how beneficial the implementation of the above-mentioned tools is. The Kaizen philosophy enables or even encourages the involvement of all employees, which makes it easier in the enterprise to implement a culture of continuous improvement at all levels in contact with the production area. The advantage of 5S are the proven effects achieved with minimal investment, which is also part of the concept of reduced production.

The improvement of production processes is continuous and requires constant improvement. The direction of improvement should result from such conditions as optimization changes and customer and market requirements, or improvements, exclusions for improving the course of the process. By presenting such an attitude and carrying out production, you can count on success and safe work in the industry sector. In the era of additions, additions, and errors that are completed and necessary.

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