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IMPROVEMENT OF THE PRODUCTION PROCESS USING LEAN MANAGEMENT – CASE STUDY

Marcin JAKUBIEC

University of Bielsko-Biala, Bielsko-Biala; m.jakubiec@ath.bielsko.pl, ORCID: 0000-0003-1874-1272

Purpose: The aim of the article is to present the benefits of using selected Lean Management elements in the production process on the example of a company producing mechanical seals.
Design/methodology/approach: The article is theoretical and empirical in nature and is based on the analysis of a selected case. In the empirical part, the analysis concerns selected elements of the production process in the examined enterprise.
Findings: The results obtained in the article refer to the benefits of using Lean Management in the production process in the analyzed enterprise. The use of identification and elimination of waste and standardization of activities at workplaces (introduction of job instructions) in selected areas of the production process allowed for the improvement of its parameters, which was presented in the article.
Research limitations/implications: The limitations in the empirical area could be the reference only to selected aspects of Lean Management and the analyzed process. Future research will cover the broader scope of Lean Management and other companies.
Practical implications: The results of the case study show the direct impact of Lean Management on the parameters of the analyzed production process. Thanks to the use of Lean Management, the process parameters have improved, which is an important factor in the context of the effectiveness of the company's functioning as a system.
Originality/value: The added value of the article is the practical presentation of the use of Lean Management to improve the parameters of the production process.

Keywords: Lean Management, production process, improvement.

Category of the paper: Research paper.

1. Introduction

The article is a theoretical and empirical study of the concept of Lean Management and the effects of its application on the example of a company producing mechanical face seals. Accordingly, the article is divided into two parts: theoretical and empirical. The theoretical part presents the assumptions of Lean Management and selected concept instruments. The assumptions indicate the basic principles of Lean Management, which they are:

1. Identification of the value stream.
2. Elimination of waste (Muda).
3. Ensuring the flow of activities in the processes.
4. Process control by means of a pull system.
5. Constant pursuit of the perfection of processes.

This part also describes the continuous improvement of Kaizen and the basic instrument of Lean Management – Value Stream Mapping.

The empirical part of the article refers to the analysis of selected areas of the production process in order to indicate the possibilities of their improvement. By using selected Lean Management assumptions, such as: identification and elimination of waste and standardization of activities at workplaces (introduction of job instructions) the following areas were analyzed: threading process of holes, balancing rotors and shafts process and wire drilling process. The use of the above assumptions of Lean Management allowed to improve the analyzed areas, among others in: operational time, tools consumption per 1000 pieces of the product, the quantity missing for 1000 items of the product, calibration of heads for every 1000 pieces of finished product, timeliness of orders and complaint's rate.

The method used in the article was a case study.

2. Literature review – meaning of Lean Management and its instruments

Lean Management constitutes a management concept that has been successfully implemented by enterprises and organizations around the world. In Poland, an increasing number of organizations can boast of successful implementations of this concept. The concept of Lean Management is of Japanese origin. It derives from the Lean Thinking philosophy, implemented in the terminology of economics and management by J.P. Womack'a, D.T. Jones'a and D. Roos'a, scientists representing the Massachusetts Institute of Technology (Womack, Jones, & Roos, 1990; Womack, Jones, 1996). It should be added, however, that the first term of lean production was used by J. Krafcik, who in 1988 published a work entitled Triumph of the Lean Production System (Krafcik, 1988, pp. 41-52). The concept of Lean Management has been developed in Toyota Motor Company as part of the Toyota Production System and has been used and developed over the years in the production plants of this brand (Lisiecka, Burka, 2016, p. 15; Bhasin, 2015). The core of the Lean Management concept is the production process, but it is now being used successfully in the service sector. The components of the so-called Toyota Production System House are shown in Figure 1.

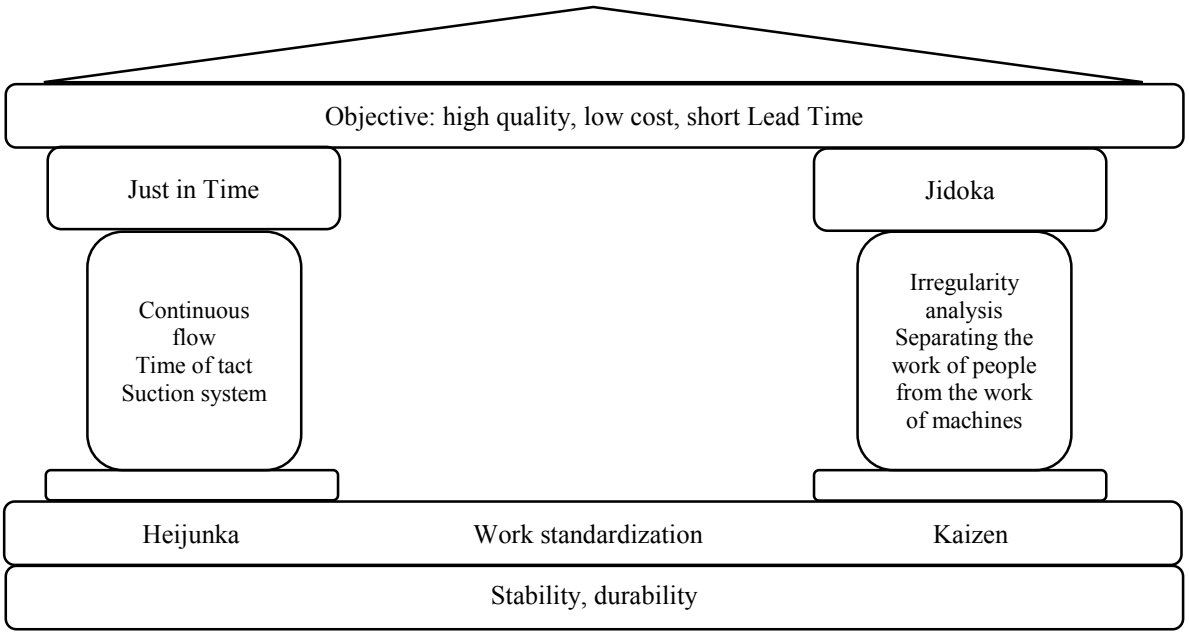

Figure 1. Toyota Production System House. Adapted from: "Lean Service w teorii i praktyce" by K. Lisiecka, I. Burka. Copyright 2006 by Wydawnictwo Uniwersytetu Ekonomicznego.

The overriding goal is high quality and low costs of the implemented processes. The basic elements of the concept, such as standardization and continuous improvement, form its foundation. They are based on continuous improvement activities such as continuous flow, irregularity analysis, Just in Time and Jidoka.

The fundamental features of the Lean Management concept are striving to improve the broadly understood quality, minimize costs and shorten the time of process implementation as a result of the systematic elimination of waste as part of management based on a flat organizational structure. Lean Management stands for process-focused management. Properly implemented principles of process management may be a factor supporting the adaptation of the Lean Management concept. Process management, aimed at achieving the synergy effect to achieve the goals of a company, has become the basis for "lean management" for the comprehensive improvement of the management system. The key goal of process management and the Lean Management concept based on it is the elimination of rigid functional structures. Instead of this ineffective model, the Lean Management concept introduces a flattened and horizontal organizational structure that focuses on processes and knowledge accumulation, while decomposing the strategic goals into the goals of processes and individual positions along the value chain. Process management in the Lean Management concept concerns not only operational processes, but also auxiliary processes, without which the proper functioning of a company would not be possible (Wiśniewska, Grudowski, 2014, pp. 34-38).

The implementation of Lean Management means the implementation of five fundamental principles on which the concept is based. These principles are:

1. Identification of the value stream.
2. Elimination of waste (Muda).
3. Ensuring the flow of activities in the processes.
4. Process control by means of a pull system.
5. Constant pursuit of the perfection of processes.

The starting point of Lean Management is value. It is created by a company, but defined by the end customer (employee/student/doctoral student). Value makes sense when it relates to a specific service that meets customer requirements, under certain conditions, e.g., a specific time. Value stream means all activities necessary to carry a service through three stages: research and development (concept, design, offering), information management (e.g., preparation of an offer) and service provision (Puvanasvaran, Megat, Tang, Muhamad, Hamouda, 2009, pp. 930-943).

The second principle of Lean Management concerns the elimination of waste, i.e., those processes and tasks that do not add value and do not participate in the process of meeting customer requirements. The essence of the Lean Management concept points to seven areas of waste (Muda), which are: waiting, unnecessary movement, overproduction, wrong process, unnecessary supplies, defects and transport (Vukadinovic, Djapan, Macuzic, 2016, pp. 43-45). Muda is a key element of control of activities in Kaizen, although other categories may also be used in it, such as: Muri – analysis of excessive workload of employees, processes, etc., and Mura – analysis of irregularities in the flow of work, documents, information, etc. The three categories mentioned above create a 3M tool that improves processes and services (Wheeler-Webb, Furterer, 2019, pp. 928-947)

These examples of waste show the heart of the problem. In the processes carried out in the company, many losses are generated that are not identified, and their occurrence generates costs. An instrument that allows Lean Management to identify and eliminate waste is Value Stream Mapping, which is described later.

The implementation of the next three principles of Lean Management is as follows. Ensuring the flow of activities in processes constitutes the principle number three. Lean Management emphasizes the essence of continuous (smooth) implementation of processes and tasks. In this way, the aim is to avoid downtime (breaks) that do not create value, and therefore to eliminate waste. The service delivery process should be a continuous flow of tasks creating its value. Another principle applies to process control through a pull system. In the pull system, the customer starts the service provision process. The processes of preparing the service and its provision will not be launched if there is no demand for it. The constant pursuit of process perfection means endless improvement. In the Lean Management concept, they are implemented through Kaizen. Kaizen is a prototype of "lean management" (Grudzewski, Hejduk, 2004, pp. 203-205).

The implementation of continuous improvement through Kaizen means that all employees, regardless of their position and functions, are involved in this process. Kaizen is based on the assumption that employees have knowledge, skills and abilities that can be better used in the interests of the company. This concept requires changes in the behavior of employees and the authority of the management. The awareness of each employee that he shapes specific processes in the company, motivates him to act, improve his qualifications, which leads to the optimization of processes, increases their quality and the quality of services resulting from these processes (Frąś, 2013, p. 264; Sigidov, Rybantseva, Moiseenko, 2014, pp. 20-30).

An important role in this respect is played by the company management, especially at the highest level. Appropriate knowledge and skills are necessary in the implementation of the Lean Management concept and continuous Kaizen improvement. The company management should conduct a diagnosis of the current state, convince employees about the legitimacy of changes, develop a plan for the implementation of Lean Management and continuous improvement, provide the necessary resources, conduct continuous communication in this area, establish roles and responsibilities for individual employees and have a vision of the company functioning after the implementation of changes (McLoughlin, Miura, 2018, pp. 3-17).

In relation to the above, the most important Kaizen principles constituting continuous improvement should be indicated (Prošić, 2011, pp. 174-175):

- discard permanent, conventional ideas in favor of innovative thinking,
- think how to perform a given activity, and not why it cannot be performed,
- instead of making up excuses, start by questioning current practices,
- perfection should not be sought immediately in action; actions can be taken even when 50% of the target achievement effectiveness is achieved,
- a mistake should be corrected immediately,
- the problem should be solved with knowledge and skills, not necessarily financial issues,
- it is desirable to use improvement tools, such as 5Why, and root causes,
- the wisdom of ten people is much more valuable than the knowledge of one.

M.F. Suárez-Barraza, J. Ramis-Pujol and L. Kerbache in the context of the rules also add: identifying, reducing and eliminating waste, team work for continuous improvement, support for company management, training of employees and the use of knowledge and experience of employees many years of experience (Suárez-Barraza, Ramis-Pujol, Kerbache, 2011, pp. 296-302).

Involving all employees in matters of quality improvement means that many problems are solved through teamwork. Team improvement in the Kaizen concept is its characteristic feature. The team is mutually dependent on the goals and tasks it is to accomplish. Teamwork allows you to achieve a better effect than working alone through joint effort. In Kaizen, significant importance is attached to the collective responsibility for reducing costs and improving results.

Each team member feels obliged to initiate changes in the workplace. In the Kaizen concept, employees focus on improving all aspects of work. Each team member is a representative of a specific profession and an expert in their field. Continuous improvement, in a way, forces employees to be active and aware of thinking and acting to seek better solutions, ways of performing work, etc. The rationalization conclusions submitted by employees in order to solve specific problems are also important.

The implementation of Lean Management principles in the practice of company operation takes place through the use of various instruments of the nature of approaches, systems, methods, techniques and tools for management and quality improvement, processes and services. The range of instruments includes: Value Stream Mapping, Kaizen, 5S, PDCA, process management, reengineering, work standardization, brainstorming, benchmarking, QFD method, FMEA method, SWOT analysis, training system, motivating system, flowchart, Ishikawa diagram, Pareto chart, checklists, 5xWhy, corrective actions, preventive actions, audit, risk analysis and others (Grudowski, Leseure, 2013, pp. 45-49; Wolniak, 2014, pp. 157-166; Jakubowski, Woźniak, Stańkowska, 2017, pp. 17-29; Feld, 2000; Parv, 2017).

One of the key instruments is Value Stream Mapping (VSM). Value Stream Mapping is a combination of slimming the organization (mainly through the identification and elimination of waste) with the improvement of service quality. Value Stream Mapping is the analysis of all activities in a process, starting with the customer and moving up the value stream to the resources needed to deliver the service. The value stream map is a graphical presentation of the flow of information and materials in the process of order fulfillment for selected services. It contains information such as: customer demand and their variability, customer requirements, the method of communication with customers, the form and duration of information flow within the organization, details of the service process, problems that hinder the implementation of the order, etc. (Maciąg, 2016a, pp. 117-118; Haefner, Kraemer, Stauss, Lanza, 2014, pp. 254-259).

Value Stream Mapping consists of three stages (Czerska, 2009, p. 45):

1. Analysis of the current state - the current value stream (Value Stream Analysis).
2. Creating a vision of the future state - the target state of the value stream (Value Stream Designing).
3. Planning the improvement and implementation of solutions (Value Stream Work Plan).

There are basic principles of Value Stream Mapping (Lisiecka, Burka, 2016, p. 101):

- mapping should start with defining customer requirements,
- you should not divide task mapping between different employees,
- there should be one leader in the entire value stream, otherwise no one will be responsible for the entire stream and part of it will remain unattended,
- mapping takes place in two stages, i.e., at the flow level (door-to-door mapping), i.e., at the level of individual component processes, and then individual activities in the process should be dealt with,
- mapping should be performed after each change in the value stream.

In each process, three types of value-added activities can be distinguished. These are: activities creating added value (in other words increasing value, i.e. those in which the properties of the service expected and accepted by the client are shaped), which do not create value, but are necessary in the process (these activities are necessary at a given level of work organization for the service to be created and meet the customer's expectations; if possible, they should be eliminated) and those that do not create added value – being a source of waste (unnecessary activities from the point of view of internal and external customers, therefore they must be absolutely eliminated) (Hamrol, 2015, p. 99; Hines, Lethbridge, 2008, pp. 53-56). The added value is created by those activities for which the customer wants to pay or those that make the customer want to use a given service.

Value Stream Mapping is both diagnostic and prognostic in nature. In the mapping work, the current state map is first created. Then, the analysis is performed, which includes such process characteristics as: processing time, share of activities that do not create value, percentage of irregularities and others, appropriate to the specificity of the mapped value stream. At further stages, problem areas are identified that require improvement, and on this basis a map of the future state is created, i.e. the target improvement of the process (Czerska, 2009, pp. 45-57; Kucheryavenko, Chistnikova, Thorikov, Nazarova, 2019, pp. 687-705).

3. Research method and results of analysis

The research method used in the empirical part of the article was a case study. In the management and quality sciences, a case study is a detailed description of a usually real economic phenomenon, e.g., an organization, a management process, its elements or the environment of an organization, to formulating conclusions about the causes and results of its course (Grzegorczyk, 2015).

A case study analysis of scientific problems can take the form of single or multiple analyzes. A single analysis is used when the studied phenomenon is of a long-term, typical, exceptional or revealing nature. The use of a single analysis is also recommended when the case is critical to the existing theory or when there is no theory relating to the phenomena under study. Multiple analysis is used when the purpose of the research is to test or improve an existing theory (Wójcik, 2013).

In the management and quality sciences, there are three goals that are served by case studies. These are the goals: theory-creating, theory-testing, and practical. The article focuses on a practical purpose, and the case study was of an application nature. It contained a description of the problem under study and the process of solving it, so explains the specific desired effects of the decisions made (Czakon, 2015).

The graphical course of the case analysis is shown in the figure 2.

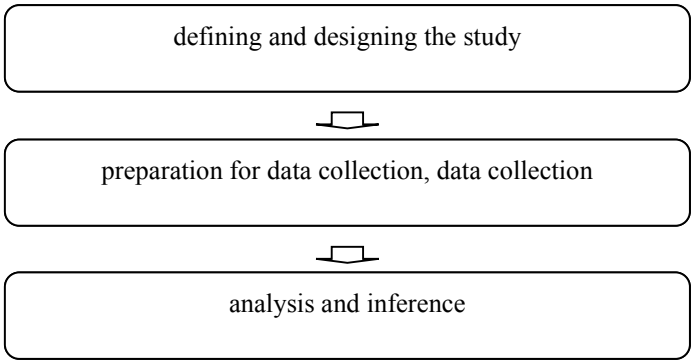

Figure 2. Case study stages. Adapted from: "Case study research, jako metoda badań naukowych" by K. Lisiecka, A. Kostka-Bochenek. Copyright 2009 by Przegląd Organizacji.

The table below shows the basic assumptions for the case study.

Table 1.
Assumptions of the case study

Items	Description
Research goals	Theoretical: description of meaning of Lean Management and its instruments useful for manufacturing company Practical: present the benefits of using selected Lean Management elements in the production process on the example of a company producing mechanical seals
Research method	Case study
The interviewees	Employees of analyzed company (managers)
Date of realization	January-March 2022

Source: personal elaboration.

The case study covered the production process within the company specializing in the production of face mechanical seals that can be used in various devices with a rotating shaft, e.g., centrifugal pumps, compressors and fans. The analyzed enterprise is 100% an enterprise with Polish capital, which has been operating on the market continuously for nearly 40 years. The company's customers are mainly pump manufacturers, as well as repair companies from many industries: food, petrochemical, energy, chemical, mining, pharmaceutical, water and sewage and others. An important element in the functioning of the enterprise is export activity. Currently, nearly half of sales go to foreign markets, incl. to Germany, the USA, France, Belgium, the Netherlands and others. All products are based on own designs and are subject to Polish and foreign patent protection. In order to provide customers with the highest quality of products manufactured in the enterprise, the activity is carried out on the basis of the requirements of normative quality management systems (ISO 9001) and the environment (ISO 14001).

The empirical analysis covered selected areas of the production process: threading process of holes, balancing rotors and shafts process and wire drilling process. The basic problem that occurred with regard to the production process was the performance of work on the basis of well-established patterns, partially documented, but without rigorous instructions and standardization. As a result of the situation, the conducted analysis of the state showed the possibility of implementing Lean Management elements such as: identification and elimination

of waste and standardization of activities at workplaces (introduction of job instructions). The analyzes of the proposed improvements were verified 3 months after their introduction. The states before and after the improvements are presented in the following tables (2-4). Below the tables there are extended descriptions of the introduced changes.

Table 2.
Analysis of the threading process of holes

Criteria	Before Lean Management	After implementation of Lean Management
Operational time	About 1h and 10 minutes	About 45 minutes
Tools consumption per 1000 pieces of the product	From 20 to 50 taps	From 12 to 35 taps
The quantity missing for 1000 items of the product	Even up to 22 pieces	About 7 pieces
Timeliness of orders	80%	94%
Complaint's rate	1,2%	0,6%

Source: personal elaboration.

1. Operational time.

The time was reduced from one hour and 10 minutes to a value of 45 minutes. The time was counted in full along with the preparation and cleaning of details. The technological instructions resulted mainly in the benefits of the selection of taps and the repair of any damage.

2. Tools consumption per 1000 pieces of the product.

The number of taps needed to make 1000 pieces of a finished product has been reduced from 20 to 50 taps to a range from 12 to 35 taps. The elimination of damage resulting from the wrong selection of the tool allowed to reduce the demand to the natural phenomenon of tool wear resulting from the friction force and torque occurring during threading.

3. The quantity missing for 1000 items of the product.

The activities allowed to reduce the quantity of the missing items from 22 to an average of about 7. We are talking about a shortage, i.e., a situation where a detail has been damaged in a way that eliminates the possibility of "saving" the product. Such damage most often resulted from the breakage of the tap, caused by the wrong choice of the tool and inappropriate cutting parameters.

4. Timeliness of orders.

The process has been improved in a way that gives a measurable benefit in the form of timely orders, as it has been improved from 80% to 94%. So, before the application of the Lean, on average, 20% of details were not shipped according to the deadline agreed with the client, and after modernization, only 6% were delayed. This phenomenon was mainly caused by the phenomenon of improving the components or making substitutes resulting from permanent damage.

5. Complaint's rate.

Complaints were reduced from 1.2% to 0.6%, which resulted in an increase in customer satisfaction. Complaints most often resulted from careless inspection of the finished product and they were already noticed at the customer's, which unfortunately had to end with official complaints.

Table 3.
Analysis of the balancing rotors and shafts process

Criteria	Before Lean Management	After implementation of Lean Management
Operational time	About 40 minutes	About 25 minutes
Tools consumption per 1000 pieces of the product	From 10 to 28 drills	From 7 to 12 drills
The quantity missing for 1000 items of the product	Up to 25 pieces	About 9 pieces
Timeliness of orders	75%	90%
Complaint's rate	0,6%	0,2%

Source: personal elaboration.

1. Operational time.

The time needed to perform a balancing operation has been reduced from 40 minutes to 25 minutes. This is a consequence of the selection of more stable balancing parameters and, what is very important, the use of the so-called initial balancing of shafts necessary for the balancing process, which resulted in faster achievement of the intended level of balancing.

2. Tools consumption per 1000 pieces of the product.

The reduction is possible due to the similarity as in the case of threading holes, the key in this topic is the appropriate selection of the tool for the balancing performed. During balancing, only the conical part of the drill works, but very often it is enough to permanently damage the drill when machining "difficult" materials.

3. The quantity missing for 1000 items of the product.

In the process of missing parts by the quality control department, parts were mainly balanced in the wrong balancing plane (most often on the wrong side). Attempts were made to supplement the damage with welds, but it was inconsistent with the customer's requirements, as most details have a material transfer feature, which means that the appropriate material is controlled from the moment of "leaving" the steelworks. The scrap rate has been reduced from 25 to 9.

4. Timeliness of orders.

Timeliness has been improved from 75% to 90% showing a significant improvement in customer satisfaction. The lack of timeliness is mainly due to incorrect balances that end in scrapping the details. Unfortunately, in this area it is better to add another piece than to expose the client to damage resulting from improper balancing.

5. Complaint's rate.

It can be seen that this indicator is small in the case of balancing, as the incorrectness of the balancing is difficult for the customer to notice in a short time. Incorrect balancing can often be noticed after years of use of the machine set, because slow damage occurs, for example, to rolling bearings, which ends with a seal service. The index was reduced with the help of precise selection of machining parameters.

Table 4.
Analysis of the wire drilling process

Criteria	Before Lean Management	After implementation of Lean Management
Operational time	About 1h and 10 minutes	About 35 minutes
Calibration of heads for every 1000 pieces of finished product	About 6 times	About 4 times
The quantity missing for 1000 items of the product	Up to 15 pieces	About 7 pieces
Timeliness of orders	85%	92%
Complaint's rate	1,4%	0,8%

Source: personal elaboration.

1. Operational time.

The time required to cut one wedge groove was significantly reduced from 1 hour and 10 minutes to approximately 35 minutes. The reason for such a significant reduction is proper mounting, not damaging the geometry of the machine and, most importantly, the ability to perform other activities while the machine is in operation.

2. Calibration of heads for every 1000 pieces of finished product.

Service activities were limited due to more thoughtful assembly of details. The impact on the structural elements was minimized, therefore the need for calibration was reduced from 6 times to 4, which resulted in a reduction of service costs.

3. The quantity missing for 1000 items of the product.

Reduction of the occurrence of shortages was possible with the help of thoughtful operation. This allowed to reduce this indicator from the level of 15 items to the level of 7 items. This reduced the amount of scrap due to the wrong position of the wedge groove and the wrong size or shape.

4. Timeliness.

The on-time ratio has been improved from 85% to 92%, which has helped to strengthen customer satisfaction with on-time deliveries. The punctuality was noticed after reducing to a minimum the amount of re-making details after the shortage process.

5. Complaint's rate.

Complaints were reduced from 1.4% to 0.8%, which was a consequence of more refined production based on technological instructions. The process of returns was basically only due to the inadequate dimension of the keyway groove.

As the above analysis showed, the application of selected Lean Management assumptions: identification and elimination of waste and standardization of activities at workplaces (introduction of job instructions) made it possible to improve selected areas of the production process. This is evidenced by the selected criteria presented in tables 2, 3 and 4. Improvements in some areas are significant and in the short term.

The use of the Lean Management concept and its instruments allows for the improvement of processes, products and services. It is important to identify the problem of what is to be improved and use the right elements of Lean Management.

4. Summary

Effective implementation of activities aimed at improving the production process involves the need to spend time both by managers and employees at various levels of the organizational structure. Lean Management strives to develop such methods of conduct to ultimately obtain appropriate profits resulting from the application of improvement actions.

The article presents the use of selected elements of Lean Management (identification and elimination of waste and standardization of activities at workplaces (introduction of job instructions)) in order to improve the efficiency of selected areas of the production process.

The classic structure of the article (theoretical and empirical) allowed for the formulation of the following goals, which were achieved:

- theoretical: description of meaning of Lean Management and its instruments useful for manufacturing company,
- practical: present the benefits of using selected Lean Management elements in the production process on the example of a company producing mechanical seals.

The verification of the improvements proved their rightness just three months after the introduction. Thanks to this, subsequent changes can be implemented, with an attitude towards the next success.

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