

Application of the Lean Management Concept in The Optimization of Production Processes: An Analytical Perspective*

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Abstract

Dynamic changes in the modern economy and growing market competition force manufacturing companies to continuously improve their processes in order to maintain and increase their competitive advantage. One of the key challenges organizations face is the need to reduce costs, improve product quality, and shorten order fulfillment times while flexibly adapting to changing customer needs. The concept of Lean Management has emerged as a response to these challenges; its essence lies in eliminating all forms of waste and creating added value for the customer.

Keywords: enterprise, lean management, production

Introduction

The purpose of this article is to present an analysis along with an attempt to optimize production processes in a selected industrial enterprise using Lean Management tools. The aim of the article is to diagnose key organizational problems, select appropriate improvement methods, and evaluate the effects of the implemented changes. The article poses two fundamental research questions regarding the identification of sources of inefficiency in production processes and the possibility of reducing them through the application of Lean tools.

This study draws on both a review of the relevant literature and empirical research in the form of a case study. The research methods employed include analysis of company documentation, direct observation of production processes, interviews with employees, and analysis of key performance indicators (KPIs) such as OEE, work-in-progress (WIP) inventory levels, and changeover times. In the practical section, selected Lean Management tools were also applied, including Value Stream Mapping (VSM), the 5S method, SMED, Kanban, and elements of TPM and Poka-Yoke, which were used for both diagnosing and optimizing production processes. The significance of the topic stems from its practical utility for companies seeking to increase operational efficiency and improve competitiveness. Implementing the Lean Management philosophy not only contributes to cost reduction but also enables the building of an organizational culture based on continuous improvement, which forms the foundation for the company's long-term development.

Lean Management as a concept for process optimization

The concept of Lean Management originated from production process management practices in Japan, and its origins are primarily linked to the activities of the Toyota Motor Corporation¹. In the 1950s, Japanese engineers, under the leadership of Taiichi Ohno and Eiji Toyoda, began work on a production system that would allow for high efficiency while maintaining flexibility in adapting to market needs. The result of these efforts was the development of the Toyota Production System (TPS), widely recognized as the foundation of the lean management philosophy².

The fundamental principle of TPS was the elimination of all forms of waste (muda), i.e., activities that do not add value from the customer's perspective. This system focused on the smooth flow of materials, inventory reduction, quality improvement, and the full involvement of employees in the production improvement process³. A key element of TPS was the introduction of

solutions such as the Just-in-Time system, which enables the delivery of components exactly when they are needed, and jidoka, i.e., the principle of stopping the process upon detection of an irregularity⁴.

The term "lean" was first used in the 1980s by researchers at the Massachusetts Institute of Technology (MIT) who were conducting an analysis of the global automotive industry⁵. The published report **The Machine That Changed the World** demonstrated that the competitive advantage of Toyota and other Japanese manufacturers stemmed precisely from different principles of organizing production processes, aimed at eliminating waste and focusing on customer value⁶.

Lean Management, also referred to in the literature as lean management, is therefore a management philosophy whose primary goal is to deliver maximum value to the customer with minimal resource consumption. It involves continuous process improvement, engaging all employees, and creating an organizational culture conducive to identifying and eliminating all forms of inefficiency⁷. In this context, lean is not merely a set of tools, but a comprehensive organizational concept, based on a long-term

perspective and oriented toward continuous process improvement. In practice, the implementation of Lean Management is based on several key principles⁸: a focus on customer-defined value, the identification and elimination of activities that do not add value, ensuring a smooth flow of materials and information, the implementation of a pull system in which production begins only when demand arises, and the pursuit of excellence through continuous improvement (kaizen).

The literature emphasizes that the effectiveness of lean management stems from its holistic nature. It is not limited to individual tools, such as 5S, Kanban, or SMED, but requires a comprehensive shift in the approach to the organization processes and fostering an appropriate work culture⁹. This means that implementing lean requires both the application of organizational techniques, as well as the commitment of management and employees at all levels.

In summary, the origins of lean management are linked to the Japanese production management model, which proved to be an effective response to market needs in the second half of the 20th century. In turn, its principles—based on the elimination of waste, customer focus, and continuous improvement—have made lean one of the most versatile and effective management concepts, applicable not only in industry but also in services, logistics, and public administration.

¹ T. Ohno, *The Toyota Production System: More Than Just Mass Production*, ProdPress.com, Wrocław 2008, pp. 23–27.

² Ibid., pp. 15–18

³ S. Borkowski, *Lean Management in Polish Manufacturing Companies*, PWN, Warsaw 2012, pp. 34–38.

⁴ J.K. Liker, *The Toyota Way: 14 Management Principles from the World's Leading Manufacturing Company*, MT Biznes, Warsaw 2005, pp. 27–30.

⁵ S. Lis, *Lean Manufacturing in Practice*, PWN, Warsaw 2016, pp. 91–95.

⁶ J.P. Womack, D.T. Jones, D. Roos, *The Machine That Changed the World*, Lean Enterprise Institute Polska Publishing House, Wrocław 2008, p. 45.

⁷ A. Hamrol, *Quality Management with Examples*, PWN, Warsaw 2016, pp. 142–145.

⁸ S. Borkowski, *Lean Management in Polish Manufacturing Companies*, PWN Scientific Publishers, Warsaw 2012, p. 33.

⁹ M. Brzeziński, *Organization and Control of Production. Production Systems and Their Structures*, WNT, Warsaw 2015, pp. 112–114.

Benefits and Limitations of Lean Management

The implementation of the lean management concept in manufacturing companies brings numerous benefits that relate to economic, organizational, and quality aspects alike. However, like any management method, lean also has its limitations, stemming from the nature of the organization, work culture, or market conditions. Understanding both the advantages and the challenges of implementing this philosophy is essential for its proper application in practice¹⁰.

The most frequently highlighted benefit of lean management is the significant reduction of waste in production processes. Eliminating losses associated with overproduction, unnecessary transportation, waiting, inventory, or defects leads to a marked increase in operational efficiency. As a result, companies can achieve higher levels of productivity with fewer resources¹¹.

The second key benefit is improved product and service quality. The use of lean tools, such as Poka-Yoke or visual control systems, helps reduce the number of errors and defects, which in turn increases customer satisfaction and reduces costs associated with complaints. Higher product quality also strengthens the company's competitive position in the market¹².

Another positive effect of lean management is the reduction of order lead times and increased production flexibility. Tools such as Kanban and SMED enable better adaptation to fluctuating demand and a rapid response to customer needs. As a result, companies can operate under small-batch production conditions, offering a wide range of products without a significant increase in costs¹³.

The literature also emphasizes the importance of lean for improving working conditions and increasing employee engagement. Tools such as 5S and Kaizen promote the creation of a safe, ergonomic work environment in which employees play an active role in the improvement process. Building an organizational culture based on shared responsibility and teamwork leads to increased motivation and job satisfaction¹⁴.

It is also significant that the implementation of lean management contributes to improving a company's financial performance. Reducing production costs, lowering inventory levels, shortening order fulfillment cycles, and minimizing complaints lead to increased profitability and financial liquidity for the organization. Lean can therefore be viewed as an effective tool for strengthening a company's market position¹⁵.

Despite its numerous benefits, lean management also faces a number of limitations that hinder its practical implementation. One of the most frequently cited problems is employee resistance to change. The lean philosophy assumes the full involvement of the workforce in the improvement process, which requires a change in existing habits, work patterns, and often additional effort. A lack of adequate communication and support from management can lead to reluctance and a decline in motivation¹⁶.

Another barrier is the lack of a long-term approach on the part of management. In many companies, Lean is treated as a set of tools for quickly improving performance, rather than as a philosophy requiring consistent implementation and the cultural transformation of the organization. This approach results in short-lived outcomes, and the company reverts to its previous methods of operation¹³.

⁽¹³⁾ J.P. Womack, D.T. Jones, *Lean Thinking: Eliminating Waste and Creating Value in the Enterprise*, ProdPress.com, Wrocław 2011, pp. 132–137.

¹⁴ M. Imai, *Kaizen: The Key to Japan's Competitive Success*, MT Biznes, Warsaw 2007, pp. 45–48.

¹⁵ S. Borkowski, *Lean Management in Polish Manufacturing Companies*, PWN, Warsaw 2012, pp. 67–70.

¹⁶ A. Hamrol, *Quality Management with Examples*, PWN, Warsaw 2016, pp. 159–162.

¹⁰ A. Hamrol, *Strategies and Practices for Efficient Operations. Lean, Six Sigma, and Others*, PWN, Warsaw 2015, pp. 114–117.

¹¹ T. Ohno, *The Toyota Production System: More Than Just Mass Production*, ProdPress.com, Wrocław 2008, pp. 29–32.

¹² Z. Zymonik, *Quality Management of Production Processes*, Difin, Warsaw 2012, pp. 88–91.

¹³ M. Brzeziński, *Organization and Production Control. Production Systems and Their Structures*, WNT, Warsaw 2015, pp. 178–180.

The literature also highlights problems associated with an excessive focus on cost reduction at the expense of innovation or organizational development. Excessive pressure to eliminate waste can lead to over-standardization of processes, limiting flexibility and the ability to introduce new solutions. As a result, the company becomes more operationally efficient but less innovative¹⁴.

Another significant limitation of lean is that not all tools can be effectively applied in every industry¹⁵. This concept was developed primarily with the automotive industry in mind, and its transfer to other sectors requires appropriate adaptation. In sectors with high demand volatility or in project-based activities, implementing lean can be difficult and may require modifications to traditional approaches¹⁶.

Implementing lean also involves initial costs, including training, workplace reorganization, and investments in information systems. A lack of adequate financial and organizational resources may limit the ability to fully implement this concept in SMEs¹⁷.

The benefits of lean management are undeniable and encompass economic, organizational, and cultural dimensions. Reducing waste, improving quality, increasing flexibility, and fostering employee engagement are the strengths of this concept and the reasons for its growing popularity worldwide. At the same time, however, lean is not without limitations; it requires a long-term approach, an appropriate organizational culture, investment in training, and a shift in mindset. Only then is it possible to achieve lasting and stable results that will allow a company to maintain a competitive advantage.

Analysis and Optimization of Production Processes

The subject of the research presented in this article is the production processes carried out at a selected industrial operating on the Polish market.

This company manufactures metal components used in the machinery and construction industries, serving both domestic and international customers. The production processes at the company in question are characterized by a moderate degree of automation, and their specific nature requires maintaining high quality while ensuring cost-effectiveness. The purpose of the study is to evaluate the efficiency of production processes and identify areas requiring improvement, followed by an assessment of opportunities to enhance the company's operations through the application of Lean Management tools. Particular attention was paid to the analysis of selected key performance indicators (KPIs), such as changeover time, work-in-progress (WIP) inventory levels, and the *Overall Equipment Effectiveness* (OEE) index.

The scope of the research includes: analysis of company documentation, observation of production processes, interviews with production staff and management, and a comparative analysis of numerical data before and after the implementation of selected lean tools.

Based on a review of the literature and the characteristics of the company under study, the following research questions were formulated:

1. What are the main sources of inefficiency in production processes at the company under study?
2. To what extent will the application of Lean Management tools improve the efficiency indicators of production processes?

Based on the above research questions, two research hypotheses were formulated:

- H1: There are significant sources of waste in the company under study, which can be eliminated through the implementation of Lean Management tools.
- T2: The application of Lean Management tools, such as 5S, SMED, Kanban, and TPM, leads to improvements in key performance indicators, particularly in reducing changeover times, lowering WIP inventory levels, and increasing the OEE rate.

The study utilized a set of methods typical of management sciences, encompassing both qualitative and quantitative approaches:

¹⁴ J.K. Liker, *The Toyota Way: 14 Principles of Management from the World's Leading Manufacturing Company*, MT Biznes, Warsaw 2005, pp. 105–107.

¹⁵ S. Krawczyk, *Logistics Process Management*, PWE, Warsaw 2011, pp. 89–92.

¹⁶ P. Grajewski, *Process-Based Organizational Management*, PWE, Warsaw 2016, pp. 151–154.

¹⁷ R. Knosala (ed.), *Production Engineering: A Compendium of Knowledge*, PWN, Warsaw 2017, pp. 241–243.

- Literature review—to define the theoretical foundations of the study and identify Lean Management tools suitable for practical application²².
 - Case study—as the primary research method, enabling a detailed presentation of the lean implementation process in a specific company³.
 - Indicator analysis—based on company data, allowing for the assessment of changes in KPI values (OEE, WIP, changeover time, scrap rate, on-time delivery)⁴.

Specific Lean Management tools were used to conduct the research, enabling the identification and reduction of waste in processes:

- Value Stream Mapping (VSM) – to visualize the flow of materials and information,
- 5S – to organize and standardize workstations,
- SMED – to reduce changeover times,
- Kanban – to improve material flow,
- TPM – to improve machine availability,
- Poka-Yoke and SPC – to reduce the number of errors and ensure process stability

The goal of the diagnosis was to identify key sources of waste in the value stream () and to determine () the potential () for reducing () lead times (), lowering () costs (), and improving process quality stability. The diagnostic process was based on the following sequence: (1) mapping the current state of the value stream (VSM), (2) gemba walks on extrusion extrusion, vulcanization, assembly, and packaging, (3) 5S audit/work standardization, (4) SMED screening in areas with high variability changeover times, (5) analysis and indicator analysis (including OEE, FPY, quality and logistics indicators), (6) cause-and-effect analysis using the 5 Whys and Ishikawa diagrams²².

1) Material flow and work-in-progress (WIP)

Value stream mapping revealed a significant imbalance between operating time and waiting time for products in inter-process queues (WIP). The flow is frequently interrupted by uneven workloads at workstations, resulting in inventory backlogs and, consequently, extended lead times and difficulties in synchronizing deliveries to customers. Gemba observations confirmed the presence of unnecessary movements (internal transport) and suboptimal workstation layout, as evidenced by the so-called “spaghetti diagrams” of secondary component flows²³. The literature emphasizes that the key factors in reducing lead time are the elimination of queues and the smoothing of workloads (heijunka), as well as the implementation of Kanban-based pull systems instead of “push” scheduling and make-to-stock production²⁴.

2) Workstation Organization and Standardization

The 5S audit revealed a lack of full standardization and failure to maintain the achieved level (S4–S5). There were scattered tools, ambiguous labeling, unclear boundaries between work and storage zones, and inconsistent documentation of work standards (different versions of instructions, lack of updates). The consequences were time wasted searching for equipment, greater susceptibility to errors, and unnecessary variability in how operations were performed. From the perspective of operational excellence, it is essential to strengthen standard work, visualization, and the discipline of daily 5S maintenance²⁵.

3) Changeovers and Production Flexibility

SMED screening confirmed increased and variable changeover times on critical machines (molds, tools, parameter settings). The predominance of internal activities over external ones resulted in long downtimes, limiting flexibility in the production of small batches and the introduction of orders

²² M. Rother, J. Shook, *See What You Don't See: Tools for Mapping the Value Stream*, Lean Enterprise Institute Poland, Wrocław 2009, pp. 23–29.

²³ R. Knosala (ed.), *Production Engineering: A Compendium of Knowledge*, PWN Scientific Publishers, Warsaw 2017, pp. 183–188.

⁽²⁴⁾ J.P. Womack, D.T. Jones, **Lean Thinking: Eliminating Waste and Creating Value in the Enterprise**, ProdPress.com, Wrocław 2011, pp. 121–128.

²⁵ A. Hamrol, *Quality Management with Examples*, PWN Scientific Publishers, Warsaw 2016, pp. 145–151

express. The literature recommends consistently moving activities to the external phase, parallelizing operations, standardizing equipment, and preparing setup templates, which leads to shorter changeover times and cycle time stabilization¹⁸.

4) Technical stability and maintenance

An analysis of failure rates and planned and unplanned downtime indicated the immaturity of TPM elements: limited autonomous maintenance (AM) capabilities, incomplete standardization of preventive inspections and insufficient analysis of the root causes of failures. Variability in MTBF/MTTR metrics translates into fluctuations in equipment availability (the OEE component), hindering a stable flow. To improve this, it is necessary to cascade TPM goals, implement AM/PM checklists, visualize machine status, and conduct regular root cause analysis (RCA) using data from MES/CMMS¹⁹.

5) Quality and Costs of Poor Quality (CoQ)

A review of qualitative results revealed discrepancies between production lines regarding FPY and defect rates. Quality control was predominantly finalstage, which led to late detection of nonconformities. The lack of widespread use of PokaYoke and SPC control charts for key characteristics contributed to variability and the need for corrections. In a systems approach, it is recommended to shift the emphasis from “fishing out” defects to prevention (jidoka, built-in quality), expand control at critical process points, and develop statistical monitoring methods²⁰.

6) Planning, Scheduling, and Tact Time

In the area of planning, discrepancies were found between the long-term sales and operations plan (S&OP/MPS) and the actual workload of workstations. The failure to align the takt time with bottleneck constraints, irregular customer order deliveries, and high volume variability resulted in an excessive number of “firefighting” changeovers and an increase in WIP. To achieve stability, it is necessary to link takt time with the bottleneck, line balancing (line balancing), as well as the use of heijunka and inter-operational supermarkets in strategic locations²¹.

7) Internal and external logistics s of inefficiency in intralogistics were identified: non-standard routes and

frequencies of internal deliveries, an inconsistent batch labeling system, and occasional material shortages accompanied by excess WIP. Consequently, there were fluctuations in ontime and in-full delivery rates (OTIF). The literature points to the effectiveness of implementing milk-run systems, material Kanban, and standardizing information flow in the supply chain (ERP/MES + EDI principles), which reduces inventory and stabilizes delivery service²².

8) Key Performance Indicators (KPI) system, reporting, and cascading of objectives

The KPI system was characterized by a wide range of metrics and limited alignment with strategic objectives. Some of the indicators were lagging metrics with no link to leading metrics. As a result, it was difficult to steer the process quickly and respond early to deviations. It is recommended to develop a Balanced Scorecard (BSC) at the plant level and cascade objectives down to work cells and workstations, taking into account metrics for throughput (takt time, capacity), quality (FPY, ppm), maintenance (OEE, MTBF/MTTR), and logistics (OTIF, inventory turnover)³¹.

9) Competencies and culture of improvement

In terms of organizational culture, the study noted the sporadic nature of Kaizen initiatives, the lack of a consistent rhythm for gemba walks (management rounds), and insufficient mechanisms for identifying and

¹⁸ S. Shingo, *The SMED System: Reducing Machine Changeover Times*, ProdPress.com, Wrocław 2008, pp. 15–22.

¹⁹ M. Brzeziński, *Organization and Control of Production: Production Systems and Their Structures*, WNT, Warsaw 2015, pp. 156–161.

²⁰ Z. Zymonik, *Quality Management of Production Processes*, Difin, Warsaw 2012, pp. 96–104.

²¹ K. Pasternak, *An Outline of Production Management*, Polskie Wydawnictwo Ekonomiczne, Warsaw 2005, pp. 118–125.

²² T. Gajewska, *Production Logistics: Systems, Indicators, Strategies*, Difin, Warsaw 2016, pp. 132–137.

³¹ R.S. Kaplan, D.P. Norton, *The Balanced Scorecard: Translating Strategy into Action*, PWN Scientific Publishers, Warsaw 2001, pp. 67–75.

disseminating best practices. Meanwhile, the effectiveness of the lean transformation depends on the involvement of all levels—from management to operators—and on developing habits of solving problems “at the source” and learning by doing²³.

10) Root Cause Analysis (RCA)

A synthesis of research findings (VSM, gemba, audits) identifies three overarching categories of causes:

- Flow instability: lack of heijunka and pull, long and variable changeover times, uncoordinated planning—resulting in excess WIP, extended lead times, and load fluctuations.
- Immaturity of process and maintenance standards: incomplete work standardization, limited 5S/visual management, insufficient AM/PM—resulting in time losses, breakdowns, and parameter variability.
- Delayed quality and a fragmented KPI system: an emphasis on final inspection over prevention, limited SPC/Poka-Yoke, and a lack of KPI cascading—resulting in rework, quality costs, and delayed responses.

Consequently, a corrective program is recommended that focuses on:

- (1) stabilizing flow (heijunka, Kanban, supermarket, SMED),
- (2) strengthening standards and TPM (5S, standard work, AM/PM, RCA),
- (3) shifting from quality control to quality prevention (SPC, Poka-Yoke, jidoka),
- (4) a balanced KPI/BSC system with daily reviews of results at the workgroup level (tier meetings).

A detailed implementation plan is presented in the following subsections.

Based on the conducted diagnosis, key areas requiring improvement were identified: excessive inter-operational inventory, prolonged changeover times, low work standardization, limited effectiveness of the quality system, and insufficient material flow. To eliminate these issues, it was necessary to apply a set of Lean Management tools that correspond to the specific nature of the company’s processes and enable results to be achieved in a relatively short time. The selection of tools was based on an analysis of improvement potential, implementation costs, and theoretical and practical experience²⁴.

First, the use of value stream mapping was planned to develop a model of the future state. VSM enables the visualization of material and information flow and allows for the identification of bottlenecks, redundant operations, and areas generating waste. Based on the current state map

a future state map was developed, taking into account the elimination of unnecessary downtime, the reduction of work-in-process inventory, and the implementation of a Kanbanbased pull system²⁵.

Another tool selected for implementation is the 5S system, which enables the organization of workstations and ensures process transparency²⁶. Particular emphasis was placed on the fourth and fifth stages (Standardization and Self-Discipline), which were underdeveloped in the company under study. At the same time, standard work was implemented, which allowed for the standardization of operational procedures, a reduction in variability, and easier onboarding of new employees. The combination of 5S with visual management (boards, pictograms, signage) fosters a culture of continuous improvement²⁷.

In the area of changeovers, the SMED method²⁸ was identified as a priority. The analysis showed that key machines had long changeover times, which limited the flexibility and efficiency of the production system. The implementation of SMED involved separating internal and external activities, performing

²³ J.K. Liker, *The Toyota Way: 14 Management Principles from the World's Leading Manufacturing Company*, MT Biznes, Warsaw 2005, pp. 55–62.

²⁴ A. Hamrol, *Quality Management with Examples*, PWN Scientific Publishers, Warsaw 2016, pp. 221–225.

²⁵ M. Rother, J. Shook, *See What You Don't See: Tools for Mapping the Value Stream*, Lean Enterprise Institute Poland, Wrocław 2009, pp. 34–38.

²⁶ M. Hammer, J. Champy, *Business Process Reengineering*, Warsaw 1996, pp. 29–33.

²⁷ P. Grajewski, *Process-Based Organizational Management*, PWE, Warsaw 2016, pp. 129–132.

²⁸ K. Oblój, *Organizational Strategy*, PWE, Warsaw 2007, pp. 98–101.

tasks in parallel, and standardizing tooling preparation. The application of this method allowed for a reduction in changeover times by as much as several dozen percent, which enabled the production of smaller batches and a more flexible response to customer orders^{29,30}.

Due to machine instability and frequent downtime, elements of comprehensive TPM maintenance were implemented³¹. Principles of autonomous maintenance (AM), which involve operators in basic maintenance activities (cleaning, lubrication, inspections), and preventive maintenance (PM), covering scheduled inspections and systematic replacement of components, were introduced. The goal of TPM is not only to reduce breakdowns but also to increase employee awareness regarding their responsibility for the technical condition of the machines³².

To improve the smoothness of material flow, a Kanban system was introduced, enabling production control using a pull-based approach. Thanks to the use of Kanban cards and labels, overproduction and excessive inter-operational inventory was reduced, and order fulfillment times were shortened. The implementation of the pull system allowed for a balanced flow and better alignment of production with actual customer demand⁴¹.

In the area of quality, preventive tools were implemented to eliminate errors at the source⁴². The use of Poka-Yoke solutions (e.g., assembly interlocks, component presence sensors) minimized the risk of errors at production stations. At the same time, Statistical Process Control (SPC) was implemented, enabling real-time monitoring of production process variability. This made it possible to respond quickly to deviations from standards and reduce quality costs⁴³.

An integral part of the optimization program was the implementation of the Kaizen system, aimed at encouraging employee engagement in reporting and implementing improvements. A formal Kaizen reporting system, regular gemba meetings, and scorecards in production departments were introduced. Employee engagement not only allowed for the elimination of simple waste but also for the development of an organizational culture conducive to continuous improvement⁴⁴.

The selection of Lean Management tools was designed to comprehensively address all areas of the identified issues. Value stream mapping enabled the creation of a vision for the future state; 5S and work standardization organized workstations; SMED reduced changeover times; TPM increased machine reliability; Kanban streamlined material flow; Poka-Yoke and SPC improved quality; and Kaizen ensured the sustainability of changes and employee engagement. The application of the above set of tools allows for the construction of an integrated system of lean management, consistent with the lean philosophy, while at the same time tailored to the specific nature of the automotive industry.

⁽⁴¹⁾ J.P. Womack, D.T. Jones, *Lean Thinking: Eliminating Waste and Creating Value in the Enterprise*, ProdPress.com, Wrocław 2011, pp. 139–144.

⁴² P.F. Drucker, *Management in the 21st Century*, MT Biznes, Warsaw 2009, pp. 56–60.

⁴³ Z. Zymonik, *Quality Management of Production Processes*, Difin, Warsaw 2012, pp. 108–111.

⁴⁴ M. Imai, *Kaizen: The Key to Japan's Competitive Success*, MT Biznes, Warsaw 2007, pp. 41–45.

Assessment of Results and Conclusions from the Implemented Measures

The assessment of the effects of implementing Lean Management in the studied company was conducted based on an analysis of selected production efficiency indicators, a comparison of results before and after the implementation of improvements, and a qualitative assessment of organizational changes. Thanks to the use of lean tools, improvements were achieved in both the operational and strategic areas, which allows for the formulation of conclusions relevant to the organization's further development. Below are charts presenting the results in specific areas.

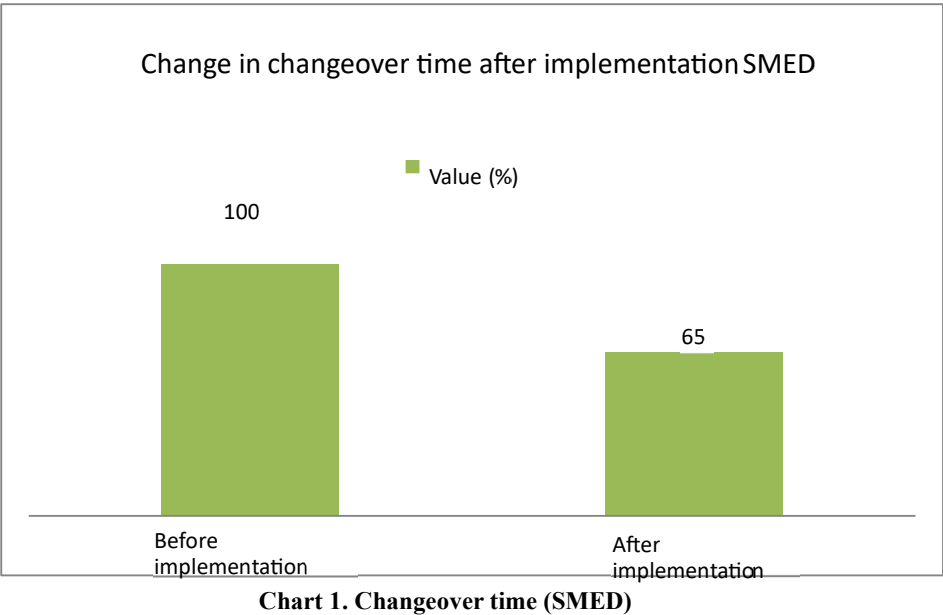
²⁹ S. Shingo, *The SMED System: Reducing Machine Changeover Times*, ProdPress.com, Wrocław 2008, pp.

³⁰ –41

³¹ R.W. Griffin, *Fundamentals of Organizational Management*, PWN, Warsaw 2017, pp. 221–225.

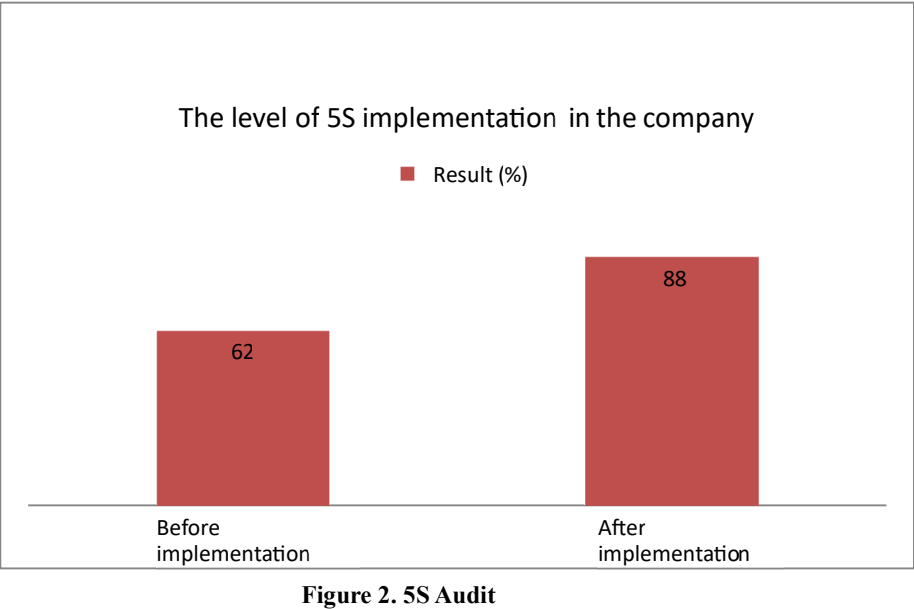
³² S. Nakajima, *TPM - Total Productive Maintenance. Fundamentals and Practice*, ProdPress.com, Wrocław 2006, pp. 77–83.

Effects in the area of efficiency and productivity



Source: author's own work

The chart shows the change in machine changeover times before and after implementing the SMED method. A significant reduction in changeover times of approximately 35% is noticeable, which confirms the effectiveness of the Lean Management tool used. The reduction in changeover times led to a decrease in downtime and an increase in production flexibility.



Source: own analysis

The chart shows the level of 5S system implementation before and after its implementation. A clear increase in the indicator from 62% to 88% was observed, which indicates an improvement in workstation organization and increased operational discipline within the company.

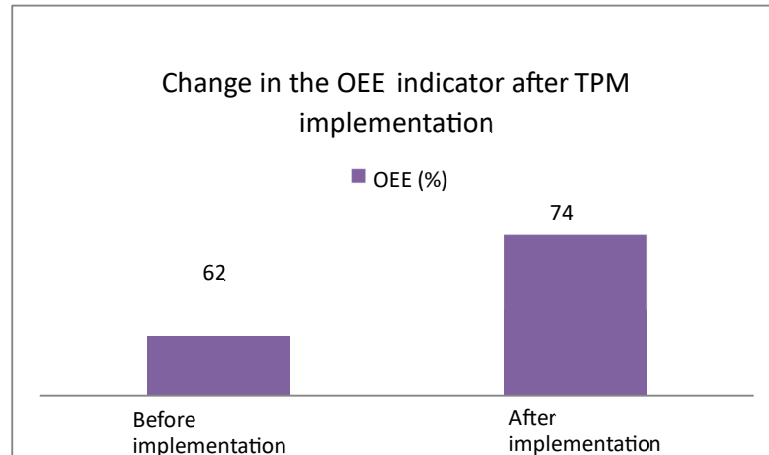
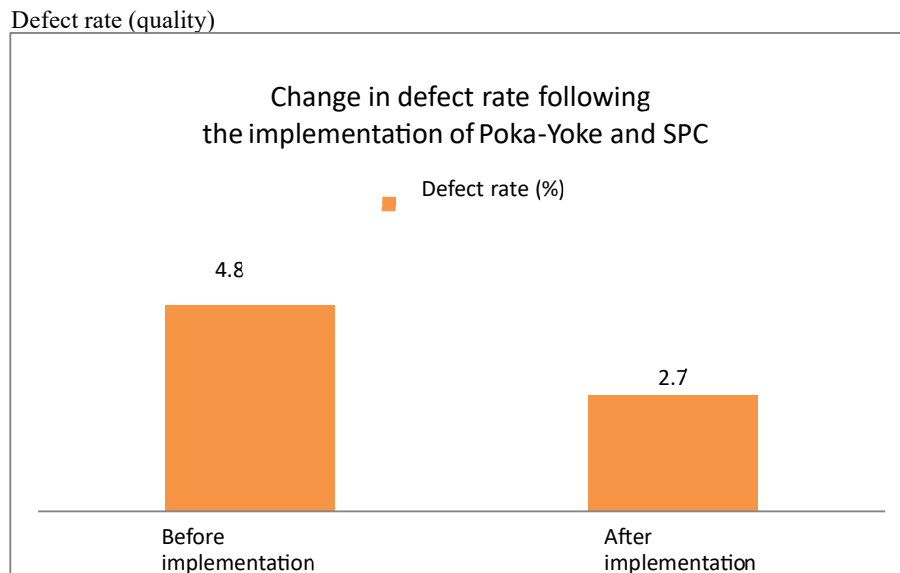


Chart 3. OEE efficiency

Source: own analysis

The OEE indicator measures the efficiency of machine and equipment utilization. As shown in the chart, its value increased from 62% to 74%, indicating improved machine availability and reduced technical downtime.

Effects on quality and customer satisfaction Figure 4.



Source: author's own analysis

The chart shows the defect rate before and after the implementation of Poka-Yoke quality tools and statistical process control (SPC). A significant reduction in the defect rate from 4.8% to 2.7% was observed, representing a reduction in quality losses of over 40%. This result confirms the effectiveness of the methods used in reducing the number of nonconforming products.

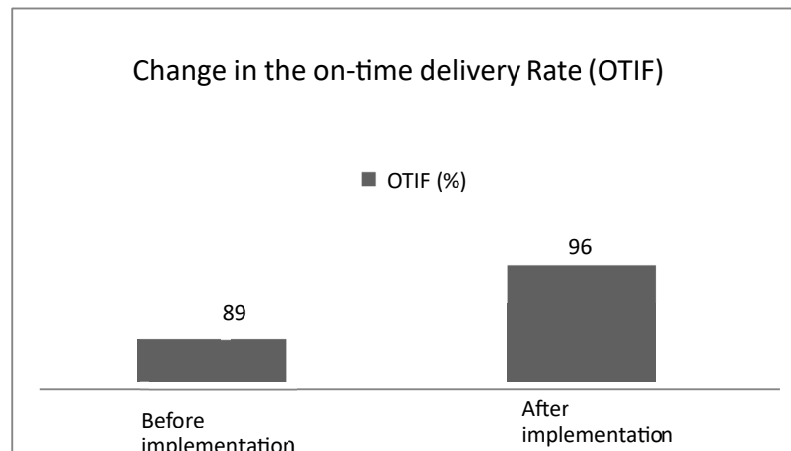


Chart 5. OTIF (On-Time In-Full)

Source: own analysis

The OTIF indicator reflects the level of on-time and complete delivery. After implementing optimization measures, its value increased from 89% to 96%, which demonstrates an improvement in the organization of logistics processes and increased delivery reliability.

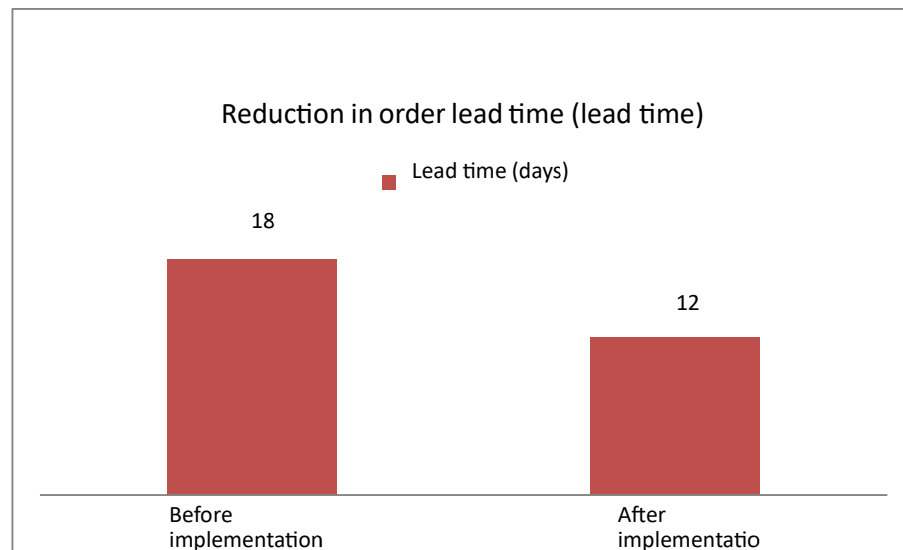


Chart 6. Lead time

Source: own analysis

The chart shows the change in average order fulfillment time. After implementing Lean Management tools, lead time was reduced from 18 to 12 business days, which represents a significant improvement in the company's operational efficiency and its ability to respond quickly to customer needs.

Summary and conclusions

The analysis of the effects of implementing Lean Management tools in the studied company allows us to draw a number of important conclusions of both theoretical and practical significance. The results clearly indicate that the implementation of Lean Management principles has contributed to a significant improvement in the efficiency of production processes in many key areas of the organization's operations.

First and foremost, the importance of a comprehensive approach to Lean Management implementation must be emphasized. The use of a set of complementary tools, such as 5S, SMED, TPM, Kanban, Poka-Yoke, and Kaizen, enabled the achievement of synergistic effects, which translated into a marked improvement in operational performance. Data analysis showed that simultaneously addressing various areas of the company's operations—

workstation organization, changeover times, machine reliability, material flow, and production quality—yielded significantly better results than when individual tools were applied in isolation.

Another key finding is the crucial role of employee engagement in the organizational transformation process. The implementation of the Kaizen system and the active participation of operators in identifying and solving production problems contributed to an increase in the number of improvement initiatives and an enhancement of the organizational culture. The results achieved, including over 150 employee-submitted initiatives and a high level of their implementation, indicate that proper staff preparation and building awareness of the importance of continuous improvement form the foundation for the effective implementation of the lean concept.

An analysis of the results also confirmed the significant impact of the implemented solutions on the company's operational efficiency. Among other things, a reduction in changeover times by approximately 35%, an increase in the OEE rate from 62% to 74%, a 28% reduction in inter-process inventory levels, and a reduction in order fulfillment times from 18 to 12 business days. This translates to improved utilization of production resources, increased organizational flexibility, and a reduction in losses resulting from downtime and overproduction.

Significant results were also recorded in the areas of quality and customer service. The implementation of tools such as Poka-Yoke and statistical process control (SPC) contributed to a reduction in defect rates from 4.8% to 2.7%, which represents a significant reduction in quality-related losses. At the same time, the increase in the OTIF rate to 96% and the improvement in the Net Promoter Score (NPS) indicate a clear increase in delivery reliability and a positive perception of the company by customers.

The sustainability of the achieved results also deserves special attention. The introduction of elements of a culture of continuous improvement, including the Kaizen system and regular 5S and TPM audits, has laid the foundation for sustaining the achieved results in the long term. This means that the implementation of Lean Management was not a one-time project but has become an integral part of the organization's operations.

At the same time, the conducted research indicates the existence of further optimization potential. Development opportunities include, among others, the integration of lean tools with digital solutions (Lean Digital), the implementation of MES-class systems supporting real-time production management, and the application of Six Sigma methods for in-depth analysis of process variability. These directions may contribute to further increases in efficiency and the strengthening of the company's competitive position.

In summary, the results of the conducted research confirm that the implementation of Lean Management is an effective tool for optimizing production processes. The achieved results are multidimensional and include improvements in operational efficiency and product quality, as well as increased customer satisfaction and employee engagement. At the same time, it should be emphasized that the success of implementation depends on consistent action, the commitment of the entire organization, and the support of management, which confirms that Lean Management should be treated as a long-term management philosophy, not merely a set of operational tools.

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