TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering

Vol. 68, Issue II, June, 2025

RESEARCH ON THE APPLICATION OF THE KAIZEN METHOD TO THE IMPROVEMENT OF THE MANUFACTURING PROCESS IN THE AUTOMOTIVE FIELD

Ionut-Nicusor TONE, Cristina Ileana PASCU, Daniel TUDORA

Abstract: *In this study we aimed to show the implementation of Lean principles in an international automobile companies and how one of the most widely used lean tools in the global manufacturing industry, the Kaizen method, is applied to improve the manufacturing process and eliminate various losses by detecting and eliminating the root cause by applying the Plan-Do-Check-Act steps and using various statistical process control methods and different quality tools such as Ishikawa Chart, 5Why, Pareto, 5W+2H, 5S-Standardized work, Visual Management, Visual Check.The deployment of Kaizen is studied in this research. Delivering quality products and services when the customer needs them, in the required quantity, at a fair price, and requiring the least amount of labor, space, equipment, material, and time is known as lean manufacturing, or production at minimal cost without losses. In the automotive industry, the Lean Manufacturing approach has evolved into a survival strategy during the 1980s in an effort to raise production quality. This study started with the presentation of the defect occurred using 5W+2H, then with process mapping using Flowchart Diagram as a first useful tool for viewing activities within a process, and it describes the essential elements of the flow. Therefore, reapplying 6S in workstation and using Fishbone Diagram, Pareto and 5 WHY, the root cause was defined, after identifying the root cause and issues that occurred during the production process, started the principles of implementing Interim Corrective Actions, Permanent Corrective Actions, the monitoring of the results using diagram histogram and finally, work was standardized.*

Key words: *Kaizen, root cause, automotive, manufacturing, lean, Ishikawa, manufacturing, waste.*

1. INTRODUCTION

When Toyota created the Toyota Production System (TPS), the Lean Principles were established in the Japanese automobile sector in an organized and integrated manner [1].

Lean Manufacturing is a production management methodology that focuses on minimizing waste and maximizing added value for customers. Lean principles were originally developed by Toyota and are now widely used in various industries to improve efficiency, quality, and delivery times [2].

Principles and Key Elements of Lean Manufacturing [3]: Value Identification: Clearly define what constitutes value for the customer from their perspective.

Value Stream Mapping: Analysis of the flow of materials and information needed to produce a product, identifying, and eliminating steps that do not add value.

Creating Flow: Ensuring a continuous and efficient flow of products and information through production processes, reducing bottlenecks and interruptions.

Pull system: Production is based on actual customer demand, not forecasts, so products are made only when they are needed. Known as the "Lean Guru" and the "father" of continuous improvement - Continuous.

Improvement, Masaaki Imai was the pioneer and leader of the spread of the Kaizen philosophy in around the world.

In 1985 he founded the "Kaizen Institute" to help companies in the introduction of Kaizen concepts, systems and tools. In 1986 he published the book "Kaizen: The Key to Japan's Competitive Success" translated into 14 languages [4]. It was the first book that

Received: 07.04.25; **Similarities**: 29.05.25: **Reviewed**: 07.04./ 07.04.25: **Accepted**:19.06.25.

introduced the "Lean" philosophy and showcased the successes of Toyota and other Japanese companies [5].

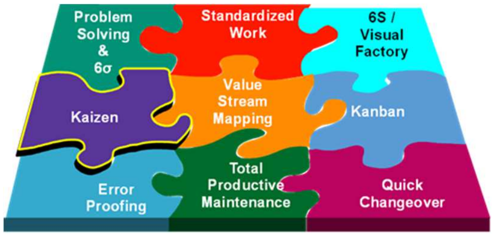

Fig. 1. Lean Tools and Techniques [5]

The KAIZEN method of continuous improvement is used in different fields, one of these fields being the automotive industry which is always developing [6].

Along with continuous development, new challenges arise, but also new possibilities for improvement in order to have a lean, error-free production that brings products and services to a higher quality with minimal costs [7].

Every business faces certain difficulties, as did an automobile manufacturer, which for a short period of time had a defect in the application of the paint coating on the bodywork, which directly affected the visual quality of the product.

As a highly prestigious company that puts quality and continuous improvement of the manufacturing process as a top priority, it immediately focused on solving the issue.

The purpose of the paper is to present how the Kaizen method was applied with the P-D-C-A steps, to present the different tools that led to finding and eliminating the root cause and finally to a loss-free production.

Fig. 2. PDCA Steps [13]

2. EXPERIMENTAL PROCEDURE

2.1 Plan

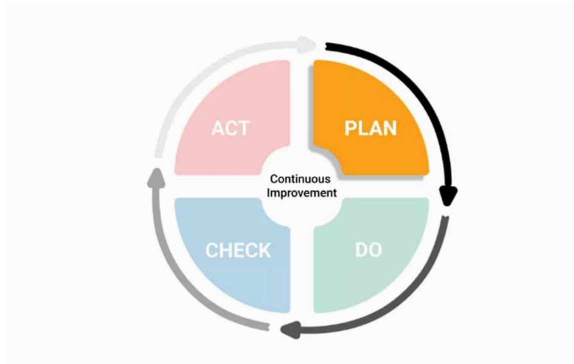

Fig. 3. Step Plan [13]

In every field, industry or activity, teamwork is regarded as one of the most effective strategies for accomplishing objectives. It is also one of the most crucial components of systems for continuous improvement since it makes information exchange, issue solving, and the growth of employee accountability easier [8].

As an experimental part, as soon as the issue was reported, in order to have a wider coverage area, to benefit from more ideas and wider experience, a team was set up to tackle the issue. For example, this team included Senior Process Engineer, Industrial Engineer, Shift Manager and Production Manager, and then the champion of the issue, the Industrial Engineer, was defined.

As is often said, the better an issue is defined, the easier it is to solve, so the team defined the issue.

The 5W2H management model is notable for its efficiency and simplicity in enterprise management, providing significant benefits in the formulation and implementation of strategies. Implementing the 5W2H model led to notable manufacturing process efficiency and tangible achievements.[9]

To define the issue, it is presented how the team used the 5W+2H method (Who, What, When, Where, Why, How, How Many) emphasizing both qualitative and quantitative data:

1. Who detected the issue?
Workstation operator;
2. What is the issue?
On one color, the bodywork shows paint spatter defects;
3. When did this issue start?
June 24, 2022, Shift - 1, Morning Shift;

4. Where was the issue detected?

At the last station on the body inspection and rework line;

5. Why is this a issue?

Affects product quality, non-conforming paint appearance (CTQ).

6. How was the issue detected?

Visually then using microscopic analysis;

7. How many parts are affected?

Various body elements are affected: Roof, C Pillar.

To be able to realize the 5W+2H method, we had to rely on different production information and we used the daily reports from each shift (morning/mid-day/night), and after monitoring and analyzing the data, the team was able to define the issue.

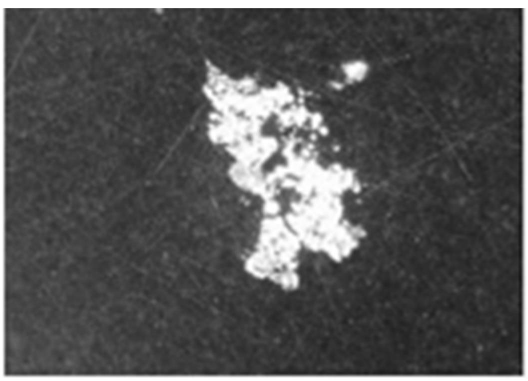

Fig. 4. Microscopic analysis

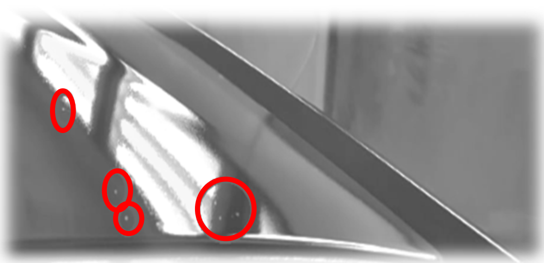

Fig. 5. NOK Surface

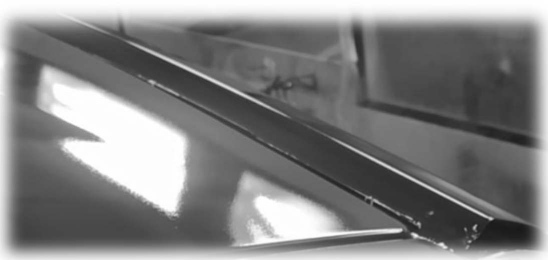

Fig. 6. OK Surface

Immediately after the detection of the issue, the microscopic analysis was performed and the measurements of the primer, paint and varnish layers were made to see if any layer is affected, the result of the measurements being OK, within the parameters respecting the standard.

After the issue has been defined, the main objective has been defined, finding out the root cause and eliminating it, making an action plan in case the issue reappears on the same color or on any other color and benefits such as eliminating different losses have been defined.

The team also made a flowchart diagram in order to have a correct picture of the manufacturing process.

Various elements of a process or operation are represented by symbols in a process flow chart. The symbols come in a variety of forms, and certain charts may use particular symbols to designate particular stages in particular procedures. The following are typical symbol forms for a process flow diagram:[10].

Square: This symbolizes a process step where there is actual work being done, or value add activities to raw materials or work in progress. Process steps should be split up into tasks and not be too general as there is the possibility of missing important sub steps or waiting/idle times which are a form of waste.

Inverted triangle: This symbolizes an inventory hold, warehouse, or work in progress inventory bin/warehouse. This is where material accumulates before being put through the next process step. It is important to identify these stores as they contribute to working capital requirements, inventory costs and can highlight other issues in the system.

Square with one rounded side: This symbol represents a delay in the system, downtime or waiting period where items have to wait on a process to finish or a certain waiting period required as part of the process. These waiting periods must be carefully measured and recorded.

Diamond: This symbol represents a decision point in the process, where there is a check, outcome or decision that must be made like a quality check.

Arrow: An arrow indicates process, material or work in progress flow through the process.

Received: 07.04.25; **Similarities**: 29.05.25: **Reviewed**: 07.04./ 07.04.25: **Accepted**:19.06.25.

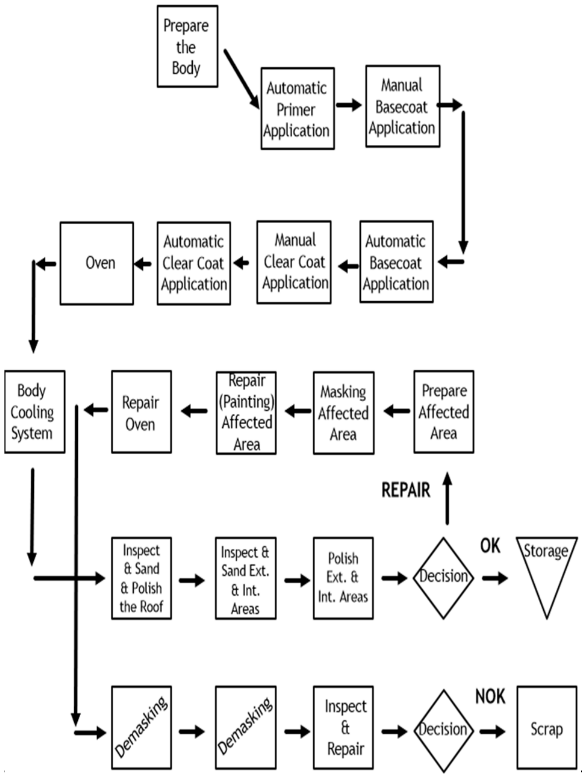

Fig. 7. Flowchart

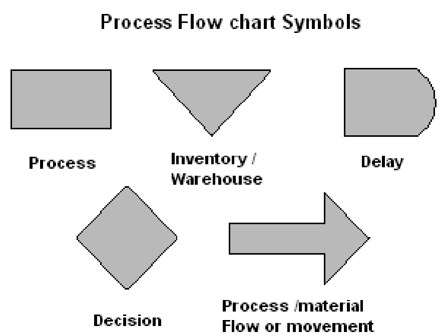

Fig. 8. Most commonly symbols used to construct a process flowchart.

The Pareto analysis technique is a methodical approach to decision-making that adeptly identifies and ranks the most significant elements influencing an issue or desired outcome.

This approach bears the name of the famous Italian economist Vilfredo Pareto, who observed that, in most cases, 20% of the factors create 80% of the outcomes.

Figure 1 displays the Pareto analysis graphic. Decision-makers can prioritize tasks for optimal effectiveness and make well-informed judgements by using the Pareto analysis approach. [6]

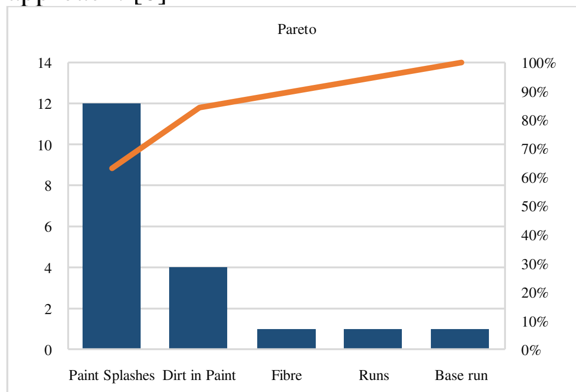

Fig. 9. Pareto analysis diagram for identifying most important cause of meters failure.

After defining the issue, analyzing the production process, and setting the priorities with the help of Pareto, the team went in parallel with the bodies involved in the production process to collect as much information as possible and to analyze them and it was observed that the issue occurs only on one color of the range offered by the manufacturer.

The issue occurs only on a certain part of the body, namely the right side and that the defect is produced only by one of the two painting booths, which contributed greatly to finding the root cause.

After using the Brainstorming method, the team drew up the Ishikawa (Fish Bone) Diagram which together with the "5 WHY? (led to the root cause.

This diagram, also called Ishikawa or Fishbone Diagram, is used to associate multiple possible causes with a single effect.

The diagram is constructed to identify and organize the possible causes for a particular single effect. Causes in Cause and Effect

Diagram are frequently arranged in four major categories.

For manufacturing cases it is Manpower, Methods, Materials and Machinery. For Administration and service sectors, it is Equipment, Policies,

Procedures and People. Ishikawa advocated the CED as a tool for breaking down potential causes into more detailed categories so that they can be organized and related into factors which help in identifying the root cause [5].

Fig. 10. Fishbone Diagram

Issue: Splashes of paint.

Possible root cause: Manual paint spray gun (Roof / C Pillar).

Why? – The appearance of paint splashes on the respective color.

Why? – Uneven paint application.

Why? – The paint spray radius is distorted.

Why? – The manual paint spray gun is not in optimal condition.

Why? – Imperceptible splashes of dry paint on the spray nozzle of the manual paint gun and its damage.

2.2 Do

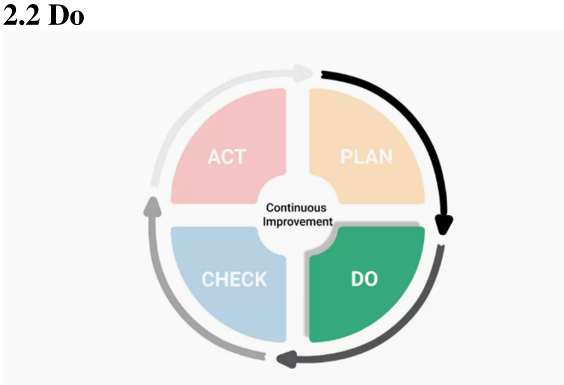

Fig. 11. Step Do [13]

In the second stage, DO, after we determined that due to the color that is rarely used on certain days, the paint dries on the spray nozzle of the spray gun, and in some situations the spray gun is also damaged, the spray radius of the spray gun is obstructed, resulting in manual application of paint in the flag area, some appearance defects hardly noticeable to the operators in the inspection line but these defects are unsatisfactory for the voice of customer fleet.

Once the root cause was identified, the team went in the root cause area, first of all it was checked according to the control plan, the working method of the operators, but it was also checked if the 6S were respected, these were strictly followed. The 5S approach is enhanced with security to create 6S. Eliminating waste in the workplace is the aim of 5S. It forms the cornerstone of lean manufacturing, with the notion being that following the use of 5S and 6S, the workplace should be orderly, devoid of superfluous goods, clean, safe, visualized, and standardized to ensure error-free production and minimal waste [2].

What is 6S? The S stands for the step's Japanese name, while the number indicates how many stages there are in the procedure.

1. Sort (Seiri)
2. Set in order (Seiton)
3. Shine (Seiso)
4. Standardize (Seiketsu)
5. Sustain (Shitsuke)
6. Safety – safety: keep safe at work. [3].

Fig. 12. Method 6S [12]

Also, together with the maintenance team, the proper functionality of the painting systems was checked, as well as the Andon (a visual signaling system to indicate production issues) and Poka-Yoke (devices or procedures that prevent human error) systems.

The first action, as ICA, was to clean with special solutions very well the spray gun intended for the color on which the issue was detected and to make several purges with the spray gun before starting the painting process.

After verifications, the results were not 100%, this corrective action being effective only in the short term, so a new corrective action was taken, that of changing the entire manual paint

Received: 07.04.25; **Similarities**: 29.05.25: **Reviewed**: 07.04./ 07.04.25: **Accepted**:19.06.25.

spray gun, even though it had not reached the change deadline, plus additional purging.

3. RESULTS AND DISCUSSIONS

/3.1. Check

Fig. 13. Step Check [13]

In the third stage, Check, the team focused on monitoring corrective actions, the second action was 100% effective, the defect no longer occurred and the root cause was completely eliminated.

Table 1

Defect Evolution

Date	**No.Of Affected Bodies**	**No.Of Total Bodies**	**Percentage**	
24 Jun	12	19	63%	**Before Corrective Action**
25 Jun	6	11	55%	**After ICA**
27 Jun	9	18	50%	
28 Jun	5	13	38%	
29 Jun	3	17	18%	
30 Jun	0	16	0%	**After PCA**
01 Jul	0	21	0%	
02 Jul	0	9	0%	
03 Jul	0	8	0%	
05 Jul	0	23	0%	
06 Jul	0	16	0%	

3.2. Act

The fourth and last stage, ACT, focused on re-training the operators on how to work, they have to continue to purge each manual paint spray gun at the beginning of each shift respecting the check sheet.

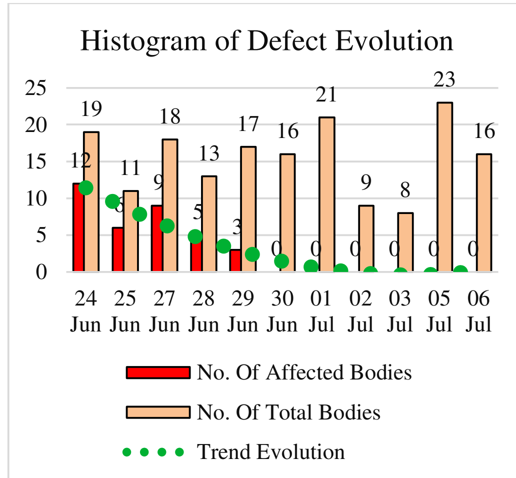

Fig. 14. Histogram

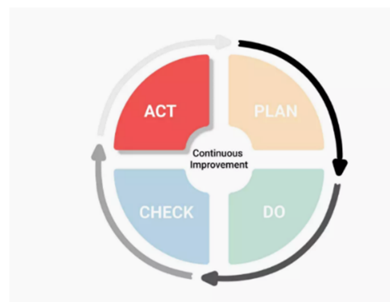

Fig. 15. Step Act [13]

Figure 16. Visual Aid

Also, the issue does not recur and affect the quality of the bodies, and team-leaders must check each paint spray gun at the beginning of each shift and sign in the check sheet if they are OK/NOK.

This new check sheet has been developed and standardized, with a visual aid to make it easier to understand.

4. CONCLUSIONS

After applying the KAIZEN method with the help of different tools, it was possible to eliminate the root cause, and the issue no longer occurred, which means that there were no more losses in the production process, and the benefits gained with its elimination brought a plus to the process, JPH increasing and cycle time was no longer affected by the percentage of repairs for the paint splashing issue.

Wastes such as: Over Processing, Human Resource, Inefficient Movements, Inventory, Quality Defects, but also costs have been eliminated, these being the raw material purchased from the supplier, high costs such as electricity, gas, overtime of operators and materials needed to repair the defect, all of which are necessary in the defect repair process.

Continuous improvement process was used (Kaizen) to completely eliminate waste and achieve perfection.

Types of Waste in Lean Manufacturing (The 7 Ways):

1. Overproduction: Producing goods before they are needed.
2. Inventory: Excessive inventories of raw materials, intermediate or finished goods.
3. Defects: The production of defective products requiring repair or replacement.
4. Transport: Unnecessary movement of materials between processes.
5. Waiting: Downtime of employees or equipment.
6. Overprocessing: Performing activities that do not add value for the customer.
7. Movement: Unnecessary movements of employees during work.

To these 7 losses, the eighth waste in Lean Manufacturing, often referred to as the "waste of underutilized talent" or "waste of underutilized human potential," was added to the traditional list of seven wastes over time as Lean practices evolved. This eighth waste emphasizes the importance of fully utilizing employees' skills, knowledge, and abilities. While there is no single definitive date when this eighth waste was universally recognized, it became more widely accepted and discussed in Lean circles during the late 1990s and early 2000s. [5, 11]

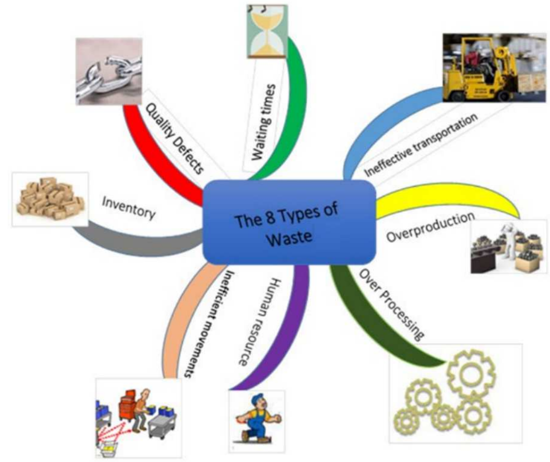

Fig. 17. The 8 Types of Waste [11]

With the application of different methods, more and more people have been familiarized to a lesser or greater extent with what lean manufacturing, Kaizen and the benefits it can bring in the manufacturing process both for the factory, reducing cycle time and at the same time increasing JPH, but also for the production staff, who can have an easier and more efficient work, as long as the quality is good, satisfying customers and their expectations and no corrective interventions are required on the bodywork.

With the completion of the Kaizen project, as it is normal, the team members and the members who were supported were congratulated, they gained confidence in them to continue with different actions that will contribute to a future leaner production, and they formed a closer bond from a relational and professional point of view, which is very useful for solving different issues as quickly as possible.

5. REFERENCES

[1] Park D., Su-Mi, Dahlgaard, Jens J., *Organizational learnability and Innovability: A system for assessing, diagnosing and Improving Innovations*, International Journal of Quality and Service Sciences, 2(2), pp.153-174, 2010.

[2] Katarína. S., *Implementation of the 6S method in an industrial enterprise.* In IOP Conference Series: Materials Science and Engineering, 1256. 012032. 10.1088/1757-899X/1256/1/012032, 2022

Received: 07.04.25; **Similarities**: 29.05.25: **Reviewed**: 07.04./ 07.04.25: **Accepted**:19.06.25.

[3] Masaaki, I *Gemba Kaizen: Quality management and improvement in the workplace*, 314, 2005, Brno: Computer Press, ISBN 80-251-0850-3.

[4] Masaaki I., *Strategic KAIZEN (TM): Using Flow, Synchronization, and Leveling [FSL (TM)] Assessment to Measure and Strengthen Operational Performance*, 2021, McGraw-Hill, New York.

[5] Pascu, C.I., *Methods Applied in Quality Engineering*, Metode applicate in Ingineria Calitatii, 2022, Universitaria Publishing House, Craiova.

[6] Dalgobind M., Anjani, Kumar A. *Application of root cause analysis in improvement of product quality and productivity,* Journal of Industrial Engineering and Management, 1(2), pp.16-53, 2008.

[7] Ananda, Mh., Burri A., Sujo O., Doddabasappa N., Anil Kumar D B., Arun. M. *Failure Analysis of Electromechanical Indicating Type Meters in an Industry by Using Fishbone and Pareto Models,* EEE Int. Conf. on Recent Advances in Systems Science and Engineering (RASSE), 2023. DOI:10.1109/RASSE60029.2023.10363516

[8] Jaca, C., Viles, E., Tanco, M., Mateo, R., Santos, J. *Teamwork effectiveness factors in healthcare and manufacturing industries,* Team Performance Management, 19(3/4), pp. 222-236, 2013.

[9] Luo, L., Hong, Q., & Zhong, M, *The application of 5W2H management model in the construction of enterprise economic and strategic management system,* Applied Mathematics and Nonlinear Sciences, 9(1), 2024. DOI: 10.2478/amns-2024-0776

[10] *Process Flow Chart Symbols,* https://www.leanmanufacture.net/operations/processflowchartsymbols/

[11] Nawras S., *The 8 Wastes of Lean* https:/theleanway.net/The-8-Wastes-of-Lean

[12] *WHAT IS 6S?* https://www.lbspartners.ie/insights/what-is-6s/

[13] *What Is the PDCA (Plan-Do-Check-Act) Cycle?* https://businessmap.io/lean-management/improvement/what-is-pdca-cycle

Cercetari privind aplicarea metodei KAIZEN la imbunatatirea procesului de fabricatie in domeniul automotive

In acest studiu se prezintă implementarea principiilor Lean într-o companie internațională de automobile, în principal metoda KAIZEN. Scopul a fost de a îmbunătăți procesul de fabricație și eliminarea diverselor pierderi prin detectarea și eliminarea cauzei radacina cu ajutorul pașilor Plan-Do-Check-Act și utilizarea diferitelor metode statistice de control al proceselor și a diferitelor instrumente de calitate cum ar fi diagrama Ishikawa, 5Why, Pareto, 5W + 2H, 6S-Lucru standardizat, Management vizual, Verificare vizuală. .Furnizarea de produse și servicii de calitate atunci când clientul are nevoie de ele, în cantitatea necesară, la un preț corect și care necesită cea mai mică cantitate de forță de muncă, spațiu, echipamente, materiale și timp este cunoscută sub numele de producție fara pierderi sau producție la costuri minime . În industria auto, abordarea Lean Manufacturing a evoluat într-o strategie de supraviețuire în anii 1980, într-un efort de a crește calitatea producției. Studiu a început cu prezentarea defectului apărut folosind 5W+2H, apoi cu maparea proceselor folosind diagrama logică ca prim instrument util pentru vizualizarea activităților din cadrul unui proces și descrie elementele esențiale ale fluxului. Prin urmare, reaplicând 6S în stația de lucru și folosind diagrama Ishikawa, Pareto și 5 WHY, cauza radacina a fost definită, după identificarea cauzei radacina și a problemelor care au apărut în procesului de producție, S-au aplicat principiile de implementare a acțiunilor corective intermediare, acțiunilor corective permanente, iar monitorizarea rezultatelor a fost realizata utilizând histograme, în final, munca a fost standardizată.

Ionut-Nicusor TONE, PhD student, University of Craiova, Faculty of Mechanics, tone_ionut98@yahoo.com, Phone: +40760119419, 107, Calea Bucuresti, Craiova, Romania.

Cristina Ileana PASCU, PhD Professor, University of Craiova, Faculty of Mechanics, ileana.pascu@edu.ucv.ro, Phone: +40744931172, 107, Calea Bucuresti, Craiova, Romania.

Daniel TUDORA, PhD, Lecturer, Alexandru Ioan Cuza University Iasi, tudoradaniel@uaic.ro, Phone: +40741990017, 11, Carol I, Iasi, Romania.