QUALITY IMPROVEMENT ANALYSIS USING THE NEW SEVEN QUALITY TOOLS AND POKA YOKE AT A SAFETY SHOES MANUFACTURING COMPANY

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ABSTRACT

This safety shoe company is a manufacturing company that faces various quality issues, such as defects in stitching, leather, mismatched shoe pairs, and incomplete components. Based on production data from March 2024 to February 2025, the most dominant defects were "Mismatched Pairs" and "Incomplete Components," with a total of 3,694 defective pairs out of 120,000 produced, resulting in a DPMO value of 7,695.83. This study aims to identify the root causes of these defects and design quality improvement solutions using the New Seven Quality Tools and Poka Yoke methods. Data were collected through field observations and literature reviews, then analyzed using tools such as the Pareto Diagram, Affinity Diagram, Interrelationship Diagram, Tree Diagram, and Matrix Analysis. The results show that immediate corrective actions include the development of standard operating procedures (SOPs), routine socialization, daily briefings, improved lighting, and component replacement. Long- term solutions, such as adding conveyor belts and implementing preventive maintenance, could not yet be executed due to time and cost constraints. Implementation efforts focused on developing a Poka Yoke-based SOP at the packing station as a concrete step toward improving product quality.

Keywords: *New Seven Quality Tools, Poka Yoke, Defect Reduction, Quality Improvement, Safety Footwear*

ABSTRAK

Perusahaan ini merupakan perusahaan manufaktur sepatu safety yang menghadapi berbagai permasalahan kualitas, seperti cacat pada jahitan, kulit, ketidaksesuaian pasangan sepatu, serta kelengkapan yang tidak lengkap. Berdasarkan data produksi selama Maret 2024 hingga Februari 2025, jenis cacat dominan adalah "Pasangan Tidak Sesuai" dan "Kelengkapan", dengan total cacat mencapai 3.694 pasang dari 120.000 pasang sepatu, serta nilai DPMO sebesar 7,695.83. Penelitian ini bertujuan untuk mengidentifikasi akar penyebab cacat dan merancang solusi peningkatan kualitas menggunakan metode New Seven Quality Tools dan Poka Yoke. Data dikumpulkan melalui observasi lapangan dan studi literatur, kemudian dianalisis dengan alat bantu seperti Pareto Diagram, Affinity Diagram, Interrelationship Diagram, Tree Diagram, dan Matrix Analysis. Hasilnya menunjukkan bahwa perbaikan yang dapat segera diterapkan meliputi pembuatan SOP, sosialisasi rutin, briefing harian, penambahan pencahayaan, serta penggantian komponen. Sementara solusi jangka panjang seperti penambahan conveyor belt dan preventive maintenance masih belum dapat direalisasikan karena keterbatasan waktu dan biaya. Implementasi dilakukan melalui penyusunan SOP berbasis Poka Yoke pada station packing sebagai upaya konkret peningkatan kualitas.

Kata kunci: *New Seven Quality Tools, Poka Yoke, Cacat Produksi, Perbaikan Kualitas, Sepatu Safety*

INTRODUCTION

This research was conducted at a safety shoes company that faces various quality issues, such as defects in stitching, leather, mismatched shoe pairs, and incomplete components. Based on production data from March 2024 to February 2025, the most dominant defects were "Mismatched Pairs" and "Incomplete Components," with a total of 3,694 defective pairs out of 120,000 produced, resulting in a DPMO value of 7,695.83. By using The *New Seven Quality Tools*, this method provide systematic approaches to analyzing and resolving quality issues, focusing on root cause identification, prioritization, and risk evaluation. Meanwhile, the Poka Yoke technique aims to prevent errors in manufacturing processes, thereby reducing product defects and enhancing customer satisfaction [1]. Quality control is a system designed to ensure that products meet established standards, with the objective of maintaining and improving quality while reducing defects in the production process. In this effort, various analytical tools are employed, one of which is the New Seven Tools of Quality, consisting of several systematic methods used to identify, categorize, and solve problems [2]. The Affinity Diagram is used to organize unstructured ideas or information into relevant categories or patterns [3]. The Relationship Diagram helps identify cause-and-effect relationships among elements of a problem [4]. The Tree Diagram visualizes hierarchical relationships between elements in diagrammatic form [5]. Meanwhile, the Matrix Diagram illustrates the relationship between two to four groups of information through rows and columns, enabling an understanding of the nature and strength of a problem [6]. Subsequently, Matrix Data Analysis presents numerical data between two sets of factors, which is then analyzed to produce quantitative values [7]. The Activity Network Diagram (AND) is used to graphically map relationships among various activities [8], while the Process Decision Program Chart (PDPC) maps potential events and their corresponding countermeasures [9]. As a complement, Poka-Yoke is also applied as part of quality management, aiming to prevent or detect errors before they actually occur in the production process [10].

RESEARCH METHODOLOGY

The research began with field observations and a literature review to obtain a comprehensive understanding of the actual conditions and the theoretical foundations relevant to the topic. This was followed by identifying the problems and determining the primary focus of the study. Subsequently, the research objectives were formulated to serve as the direction for the entire research process. After setting the objectives, the scope of the study was defined to ensure a more focused and structured investigation. Data collection involved both primary and secondary sources. Primary data were obtained directly from field observations, while secondary data were gathered from documents, reports, and other written sources. The collected data were then processed, particularly focusing on defect data. This data was further analyzed using the New Seven Quality Tools. Based on the analysis results, quality improvement solutions were designed by applying the Poka-Yoke method, which aims to prevent errors from occurring early in the production process. A summary of the research methodology is illustrated in Figure 1.

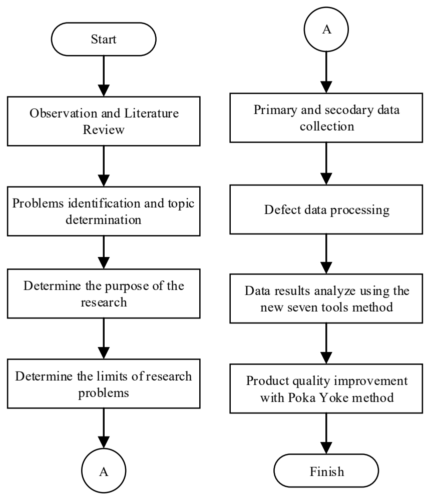

Figure 1. Research Methodology Flowchart

RESULTS AND DISCUSSION

Production and Defect Data

Production and defect data were collected over a 12-month period, from March 2024 to February 2025. During this period, the following defects were recorded: stitching defects 645 pairs, leather defects 693 pairs, mismatched pairing 1,289 pairs, incomplete components 1,067 pairs. This results in a total of 3,694 defective pairs out of 120,000 total produced pairs.

The next step was to calculate the Defect Per Million Opportunities (DPMO), which was found to be 7.695,83

$$DPMO = \frac{Total\ Defect}{(Total\ Productions\ x\ Total\ Defect\ Probability)} x1.000.000$$

$$DPMO = \frac{3.694}{(120.000\ x\ 4)} x1.000.000$$

$$DPMO = 7.695{,}83$$

To further understand the distribution of product defects, a Histogram was created (Figure 2),

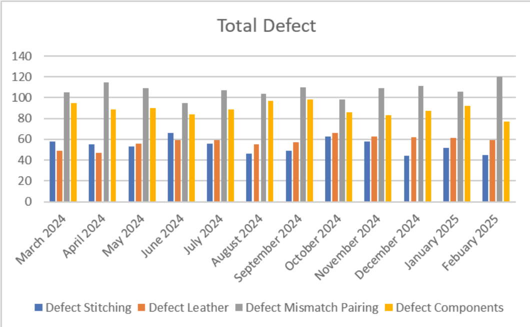

Figure 2. Defect Product Histogram

Followed by the calculation of defect percentages and cumulative defects, as shown in Table 1.

Table 1. Defect Percentages and Cumulative Defects

Type of Defect	Total Defect (pcs)	Defect Percentage (%)	Cumulative Percentage (%)
Stitching	645	17.46	17.46
Leather	693	18.76	36.22
Mismatched Pairing	1289	34.89	71.11
Components	1067	28.88	100
Total	3694	100	100

A Pareto Diagram was also developed (Figure 3) to highlight the most frequent defects.

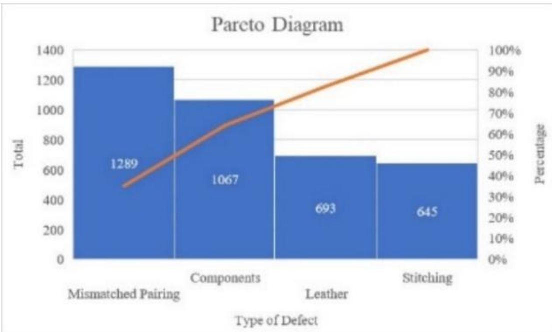

Figure 3. Pareto Diagram

Cause of Defects

A list of the identified problems and contributing factors to product defects is presented in Table 2.

Table 2. List of Problems

No	List of Problems
1.	Operator negligence while on duty
2.	There are no regulations (SOPs) for the packing station
3.	Lack of concern of operators when carrying out their work
4.	Operators too much talking while doing their work
5.	Lack of briefing for each operator
6.	Putting the production results in a mess
7.	Manual machine
8.	Lack of maintenance on the machine
9.	Lack of regular training for operators
10.	The quality of the raw materials is inconsistent
11.	Lack of lightning for the quality check station
12.	The distance between the production station is too far

Data Analysis Using the New Seven Tools

Data analysis using the New Seven Tools helps identify root causes of problems and guide quality improvement efforts.

1. Affinity Diagram

The causes of defects were categorized into five groups. This classification helps identify focus areas for improvement (Figure 4).

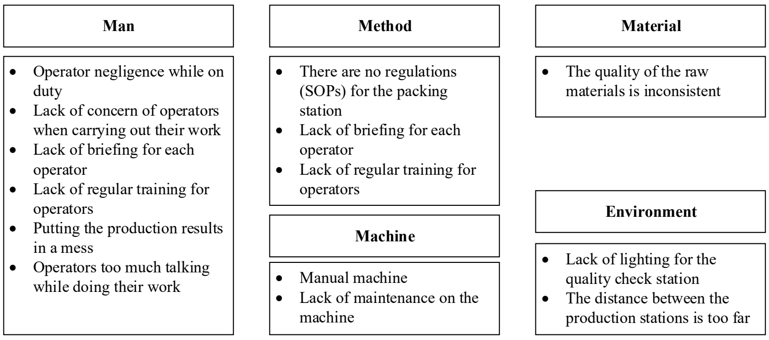

Figure 4. Affinity Diagram

The Affinity Diagram categorizes defect causes into five groups: Man, Method, Material, Machine, and Environment. Issues include operator negligence, lack of SOPs and training, inconsistent raw materials, poorly maintained manual machines, inadequate lighting, and long distances between production stations. This helps identify key areas for quality improvement.

2. Interrelationship Diagram

This diagram mapped cause-and-effect relationships among the identified issues, highlighting the most influential root causes (Figure 5).

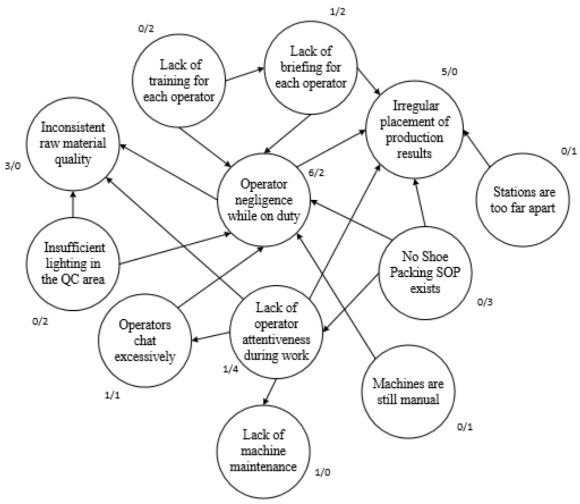

Figure 5. Interrelationship Diagram

The Interrelationship Diagram shows that "Operator negligence while on duty" is the most influential root cause, with the most outgoing effects to other issues. This highlights the need to prioritize improvements in operator discipline and performance.

3. Tree Diagram

The Tree Diagram provided a structured breakdown of proposed solutions, which included improving operator performance, work environment, machine productivity, and material quality (Figure 6).

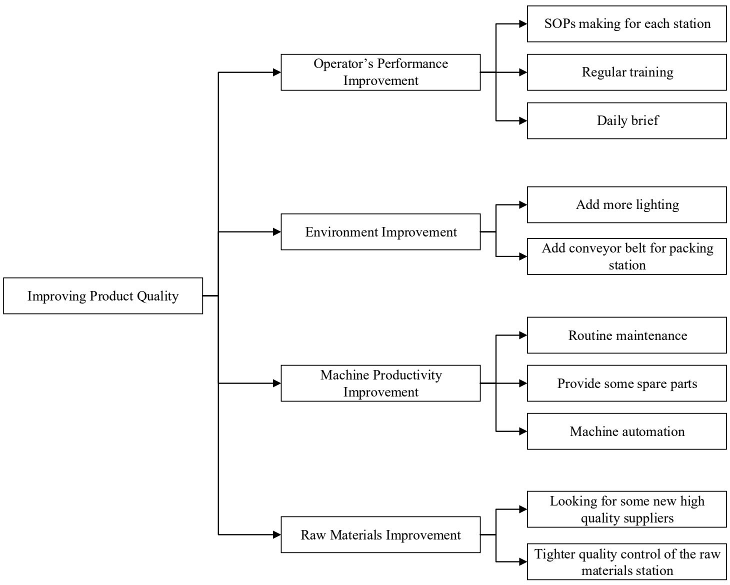

Figure 6. Tree Diagram

The Tree Diagram outlines solutions to improve product quality through four main areas: operator performance, environment, machine productivity, and raw materials. Each area includes specific actions, such as creating SOPs, adding lighting, and others.

4. Matrix Diagram

The Matrix Diagram (Figure 7) was developed to evaluate the interrelationships among problem factors, offering insight into their relative influence and connection.

	Improvement Plan			
Problem Factors	Improving Operator Performance	Improving Machine Productivity	Improving Work Environment	Improving Material Quality
Operator	■	▲	▲	■
Machine	▲	■	▲	●
Environment	▲	●	■	●
Material	▲	●	●	■
Improvement Suggestions				
Creating SOP	■	▲	▲	▲
Conducting Training	■	▲	●	●
Holding Daily Briefings	▲	▲	▲	●
Adding Lighting	■	●	■	▲
Adding Conveyor Belt	▲	●	■	●
Routine Maintenance	▲	■	▲	●
Providing Spare Parts	▲	■	●	●
Machine Automation	▲	●	●	●
Finding Best Supplier	▲	●	●	■
Tightening Raw Material QC	▲	●	●	■

Legend
■ Very Related
▲ Related
● Not Related

Figure 7. Matrix Diagram

The Matrix Diagram evaluates the relationships between problem factors and improvement plans, showing the strength of each connection using symbols (very related, related, not related). It highlights that actions like creating SOPs, conducting training, and machine automation are strongly linked to multiple areas of improvement, especially operator performance and machine productivity.

5. Matrix Data Analysis

This tool was used to prioritize improvement actions based on urgency and importance (Table 3).

Table 3. Matrix Data Analysis

Primary	Secondary	Importance	PT XYZ
Improvement of operator performance	Creating SOPs for each station	5	2
	Conducting regular training	5	2
	Holding daily briefings	4	1
Improvement of environment productivity	Adding lighting in the factory	4	2
	Adding a conveyor belt at the packing station	3	1
Improvement of machine productivity	Performing regular maintenance	5	2
	Providing spare parts	3	1
	Machine automation	3	1
Improvement of raw material quality	Finding suppliers with the best quality materials	4	2
	Tightening QC in the raw material	4	3

The Matrix Data Analysis prioritizes improvement actions by evaluating their importance and urgency for PT XYZ. The top priorities include creating SOPs, conducting training, and performing regular maintenance, as they score highest in both importance and relevance to the company.

6. Activity Network Diagram (AND)

The production processes for EVA and safety shoes were analyzed (Tables 4 and 5).

Table 4. Production Process for EVA

No.	Work Process	Code	Start
1	Preparation of insock and eva lining fabric according to the order	A	-
2	Cutting of insock and eva lining fabric	B	A
3	Pressing eva and fabric. The eva and fabric will be stacked and pressed using a high-temperature machine	C	B
4	Final cutting process. The combined eva + fabric are trimmed again	D	C

Table 5. Production Process of Safety Shoes

No.	Work Process	Code	Start
1	Pouring process or outsole molding using PU machine with a pouring system	A	-
2	Gluing the outsole with the upper using special adhesive	B	A
3	Sewing the outsole and upper, done to strengthen the bonding between outsole and upper	C	B
4	Attaching insock into the already assembled outsole and upper	D	C
5	Quality control process, inspecting the shoes to ensure they meet the standards	E	D
6	Repairing process, conducted if the shoes require repairs	F	E
7	Packing process, where finished and standard-compliant products are packed with accessories such as shapers and wrapping paper	G	F

And then mapped graphically to visualize the flow and interdependencies among processes (Figure 8).

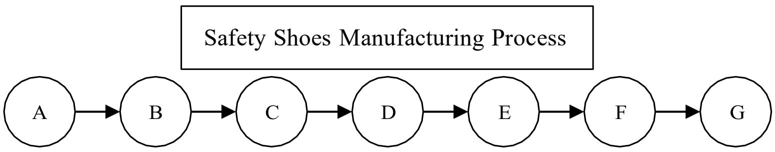

Figure 8. Activity Network Diagram

The Activity Network Diagram outlines the step-by-step flow and dependencies in the production processes of EVA and safety shoes. For safety shoes, the process follows a clear sequence from outsole molding (A) to packing (G), highlighting the linear and interrelated nature of each production stage.

7. Process Decision Program Chart (PDPC)

PDPC was used to anticipate potential problems and recommend corrective measures. It consisted of four stages: identifying improvement steps, potential problems, and contingency plans (Figure 9).

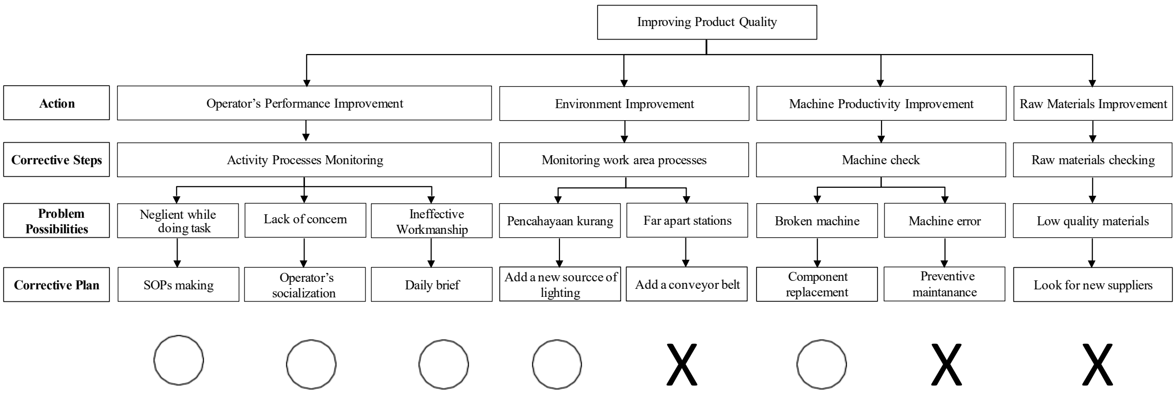

Figure 9. Process Decision Program Chart (PDPC)

The Process Decision Program Chart (PDPC) outlines improvement actions, anticipates potential problems, and suggests corrective plans across four areas: operator performance, environment, machine productivity, and raw materials. It helps prepare contingency actions—such as SOP creation, adding lighting, or component replacement—to minimize the risk of failure during quality improvement implementation.

In the diagram, actions marked with a circle represent improvement plans that are feasible to implement, as they are manageable within the available resources. Meanwhile, actions marked with an "X" indicate those that cannot be carried out due to budget and time constraints**.** These limitations prevent the execution of improvements such as adding a conveyor belt, implementing preventive maintenance, and sourcing new suppliers.

Poka-Yoke Implementation

Based on the identified problems and proposed solutions, several corrective actions were recommended. These included: developing Standard Operating Procedures (SOPs), conducting regular socialization and daily briefings, improving lighting in critical areas, replacing faulty components. As a concrete implementations, a Poka-Yoke-based SOP was developed specifically for the packing station, as illustrated in Figure 10.

Standard Operational Procedure (SOP) Shoe Packing

Department:
Effective Date:

Objective:
To prevent left and right shoes from being swapped and to avoid missing components during packing.

Procedure:

No.	Activity	Potential Error	Explanation	Poka-Yoke Used	Poka-Yoke Type
1	Physical inspection of shoes	Defects on glue, stitching, leather	Ensure the shoes meet QC standards	Visual checklist on each point (glue, stitching, leather)	Detection
2	Take and place shoes into the box	Wrong pairing of shoes placed in box	Left and right shoes must be placed in their designated positions	Use partition designed to match shoe shape (rejects incorrect shape)	Prevention
3	Insert packing materials (shaper and wrapping paper)	Shaper or wrapping paper missed during packing	Ensure both shaper and wrapping paper are included	Use packing checklist before box closure	Detection
3	Close the box and attach external stamp	Mistake in writing information on the box	Use a stamp on the box to avoid human error	Stamps with different colors for different models	Prevention
4	Submit to final QC department	-	Rechecked by QC personnel	QC has a checklist	Detection

Notes:
- Use only new boxes with inner partitions.
- If the shoes don't fit, don't force them - they may be on the wrong side.
- All steps must be completed before packing proceeds to the next unit

	Name	Position	Signature
Prepared By			
Checked By			
Approved By			

Figure 10. SOPs Developments for Packing Station

The Standard Operational Procedure (SOP) for Shoe Packing aims to prevent errors such as mismatched shoes and missing packing components. It identifies potential mistakes at each step and applies Poka-Yoke methods—simple error-proofing techniques—to either detect or prevent those errors. For example, visual checklists and QC rechecks serve as detection Poka-Yoke, while partitions and color-coded stamps are prevention Poka-Yoke that stop mistakes before they occur.

SUMMARY

The implementation of the New Seven Quality Tools combined with Poka-Yoke methods has proven effective in improving the quality of safety shoes by reducing product defects. The main defects identified—mismatched pairs, incomplete components, stitching issues, and leather defects—were traced back to causes related to human error, methods, machines, materials, and environmental factors. By introducing written and verbal regulations, standard operating procedures, daily briefings, and shoe-shaped foam partitions during packing, the production process became more error-proof. As a result, significant reductions in defect rates were achieved, including a drop in mismatched pairs from 13% to 0% and in incomplete components from 11% to 3%, demonstrating the success of the improvement measures.

CONCLUSION

The study identified four main types of defects in the safety shoe production process: stitching defects, leather defects, mismatched pairs, and incomplete components. Based on production and defect data collected over a 12-month period (from March 2024 to February 2025), a total of 3,694 defective pairs were found out of 120,000 pairs produced. This resulted in a DPMO (Defects Per Million Opportunities) value of 7.695,83. By applying the New Seven Quality Tools, several improvement plans were formulated according to their level of urgency. Immediate actions included the development of Standard Operating Procedures (SOPs)**,** conducting socialization sessions, implementing daily briefings, improving lighting in the work environment, and replacing worn-out components. However, long-term actions such as the addition of conveyor belts, preventive maintenance, and the search for new suppliers could not be implemented due to time and cost constraints. Therefore, the most feasible and impactful step taken was the implementation of a Poka-Yoke-based SOP at the packing station to enhance production quality and minimize human error.

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