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Lean Six Sigma Implementation to Reduce Rubber Sole Waste in the Manufacturing Company

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ABSTRACT

The aim of this study is to carryout research about the waste of rubber sole in the one of the rubber sole company in Tangerang. The company has a problem due to the amount of rubber sole waste is 5.5% over the company's standard, namely max.3.0%. There are 5 (five) largest type of rubber sole defect. They are dents, contamination, colour bleeding, lack of material and bubbles. To find out the factors that cause defects and how to provide suggestions for improvements to the problem. This research using the Lean Six Sigma method with the DMAIC approach (define, measure, action, improve, control). Furthermore, to find out the root cause of the problem will be using fishbone diagram tool and proposed improvements using the 5W+1H and FMEA. The purpose of the research is to find out the factors that cause of rubber sole waste over than company standards. The results of the research after making some improvements using 5W+1H and FMEA. The waste of the rubber sole is reduced to 1.1%.

Key Words: Define, Measure, Action, Improve, Control (DMAIC), Quality, Rubber Sole, Six Sigma, Waste.

1. INTRODUCTION

Every company certainly requires a mature business strategy in order to compete in the target market segment. This strategy is not only to support the success of business processes and increase profitability, but also to manage the quality of the company so that it has strong value and competitiveness in the market. One of the best methods to make this happen is lean six sigma. Quality control that is implemented properly will have an impact on the quality of the products produced by the company. The quality of the products produced by a company is determined based on certain dimensions and characteristics. Even though the production processes have been carried out properly, in reality there are still process errors where the quality of the product produced is not in accordance with the specifications or in other words the product produced is damaged or rejected resulting in waste.

In terms of quality improvement there are many ways or methods that can be used, one of which is the Lean Six Sigma method. The Lean Six Sigma method is often used by companies to improve product quality by minimizing the number of reject products. The Lean Six Sigma application focuses on how to reduce product defects, starting with identifying elements critical to quality (critical to quality) of a process to providing suggestions for improvements related to product defects that arise. Because every company will try as much as possible to produce products that can meet consumer desires [1, 3-4, 15-16].

One of the well-known manufacturing companies in Banten province, located in Tangerang district, is a company engaged in the production of rubber soles. Rubber sole is one component of footwear. Due to the very high market demand and the large number of competitors in the same industry, the quality of the products produced must be maintained so that customers are satisfied using these products. The quality of the rubber sole products produced is satisfactory to customers, but one of the problems that occurs is the waste rubber sole produced for 6 months from rubber sole products does not comply with company standards, namely a maximum of 3.0%.

The following is the target data for compound rubber production and the actual compound rubber production results which can be seen in table 1 below.

Table 1. Data Output and Waste Rubber Sole

Jun 2022 - Dec 2022

Month	*Output (pasang)*	*Output (kg)*	*Waste (kg)*	%
June	1,106,687	376,274	19,062	5.1
July	1,036,547	352,426	18,294	5.2
Aug	902,312	306,786	14,834	4.8
Sept	813,404	276,557	16,461	6.0
Oct	843,327	286,731	15,830	5.5
Nov	893,931	303,937	17,161	5.6
Dec	871,942	296,460	10,006	3.4
Total	**6,468,150**	**2,199,171**	**111,648**	**5.1**

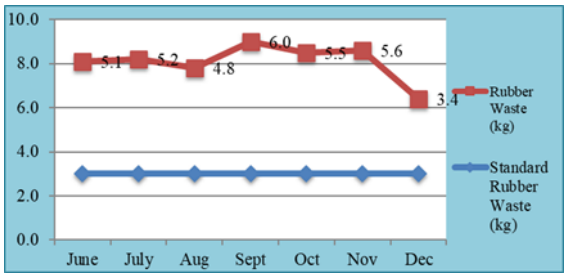

Figure 1. Grafik Prosentase Waste Rubber Sole

Based on the Table 1 and Figure 1 above, it can be seen that the waste rubber sole during the period June 2022 - Dec 2022 could not be achieved in accordance with the company's standard of max.3.0%. The cause of the standard not being achieved is due to the large number of defective products that are not in accordance with predetermined quality standards.

The following are 5 (five) types of rubber sole defects as shown in Figure 2.

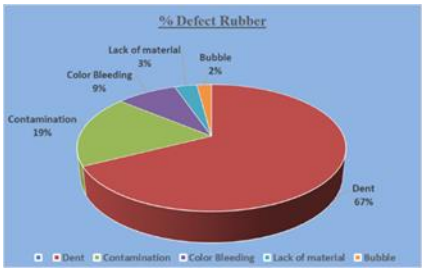

Figure 2. Grafik Prosentase Defect Rubber Sole

Based on the above data, there are 5 (five) types of rubber sole defects, namely: Dent (67.5%), Contamination (18.5%), Colour Bleeding (8.7%), Lack of material (3.2%) and Bubble (2.1%).

2. METHODOLOGY

2.1 Lean Six Sigma

Lean Six Sigma is a managerial approach that focuses on teams and seeks to improve performance by eliminating waste and defects. As the name implies, this method is a combination of six sigma and lean manufacturing/lean enterprise philosophy. The application of this method aims to eliminate waste of physical resources, time, and labour, while ensuring quality in the production process and organization. This method will help companies to eliminate the seven wastes that occur in the production process and minimize defects per million opportunities (DPMO). Simply put, with the application of this method, any use of resources that do not create value for the end customer (customer value) is a waste and must be eliminated.

2.2 Quality Control

Control is a tool for management to repair products when needed, maintain high product quality and reduce the number of damaged products.

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According to Montgomery, D.C [9] defines that quality control is an engineering and management activity, with which we measure product quality characteristics, compare them with specifications or requirements and take appropriate health measures if there is a difference between actual appearance with standard ones. According to [8] quality control can be interpreted as activities carried out to monitor activities and ensure actual performance.

According to Tjiptono in [12] Product quality is quality which includes efforts to meet or exceed customer expectations; quality includes products, services, people, processes, and the environment; quality is a state of constant change (eg what is considered quality today may be perceived as less quality in the future).

2.3 Definition of Seven Tools

Seven Tools (Seven Quality Control Tools) – QC Seven Tools are 7 (seven) basic tools used to solve problems faced by production, especially on issues related to quality (Quality). The 7 basic QC tools were first introduced by Kaoru Ishikawa in 1968. The seven tools are Check Sheets, Control Charts, Cause and Effect Diagrams, Pareto Diagrams, Histograms, Scatter Diagrams and Flowcharts.

2.4 Six Sigma

Six Sigma is a new management tool that is used to replace Total Quality Management which is very focused on quality control by exploring the company's overall production system. Has a goal to eliminate production defects, cut product manufacturing time, and eliminate costs. Six sigma is also called a comprehensive system - meaning strategies, disciplines, and tools to achieve and support business success

2.5 Six Sigma Implementation

DMAIC Stages: There are 5 Stages used by Six Sigma in solving problems known as the DMAIC Method. Following are the 5 Stages of DMAIC:

2.5.1 Define

The first DMAIC stage in Six Sigma is DEFINE, which is the stage for defining and selecting problems to be solved along with costs, benefits and impacts on customers. The tools used in the Define stage include Function Deployment Process Map

- SIPOC Map (Diagram Supplier, Input, Proses, Output dan Customer)
- Pareto Chart
- FMEA (Failure Mode Effect Analysis)
- Affinity Diagram
- Relation Diagram
- Cause and Effect Analysis (Fishbone Chart dan Cause and Effect Matrix)

2.5.2 Measure

Measurement is the step of measuring the problems that have been defined to be solved. In this stage there is data collection which then measures the characteristics and capabilities of the current process to determine what steps must be taken to make improvements and further improvements.

The main things that must be done in this case are:

1) Determine key quality characteristics, here quality characteristics or CTQ

2) Measurement of baseline performance of quality characteristic attributes at the output level. Before a product can be declared as defective or failed, the criteria for failure or disability must be defined first.

2.5.3 Analyze

The Analysis Stage is the stage for finding solutions to solve problems based on the identified Root Causes. In this Stage, we must be able to analyze and validate the Root Causes or solutions through hypothesis statements**.**

2.5.4 Improve

After obtaining the Root Problems and Solutions and validating them, the next step is to take corrective action on these problems by conducting tests and experiments to be able to optimize these solutions so that they are really useful for solving the problems we are experiencing.

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2.5.5 Control

The purpose of the control stage is to establish standardization and to control and maintain the process that has been repaired and improved in the long term and to prevent potential problems that will occur in the future or when there is a change in process, workforce or management change.

The tools used in the control stage are Poka Yoke (Mistake Proofing)

- Process Control Plan
- Process Control Chart

According to [2] the specific control tasks that must be completed by the DMAIC team are:

1. Develop a monitoring process to track changes to be determined.

2. Create a response plan to deal with problems that may arise.

3. Help focus management attention on critical measures that provide up-to-date information about the results of the project (Y) and on key process measures (X).

5.6 Failure Mode and Effect Analysis (FMEA)

The Failure Mode and Effect Analysis (FMEA) method is an instructed procedure to identify and prevent as many risks as possible that play a role in a failure through a top down approach. FMEA is a well-structured method for identifying risks from system and operational failures and reducing the possibility of these defects. According to [7, 10-11,14] Failure Mode and Effect Analysis is a tool used in quality improvement methods.

5.7 Risk Priority Number (RPN)

The value of the Risk Priority Number (RPN) is a product of the multiplication of the severity level, occurrence rate and detection rate. RPN is to determine the priority of failure. RPN has no value or meaning. The RPN value is used to rank potential process failures.

The Risk Priority Number (RPN) value can be represented by the following equation:

RPN = severity x occurrence x detection .....(1)

RPN = S x O x D .....(2)

Keterangan:

RPN = Risk Priority Number

S = Severity

O = Occurrence

D = Detection

The next step after calculating the Risk Priority Number (RPN) value is using the value to take corrective action based on the level of results from the highest to the lowest value. Maximum RPN value [5],[6],[13],[17]

3. RESULTS AND DISCUSSION

3.1 Define Stage

At this stage, defining the problem and determining the goal is to find the root cause of the problem from the large number of rubber sole defects resulting from the production process. The steps taken at this stage include preparation of SIPOC (Supplier, Input, Process, Output, and Customer) diagram.

The purpose of preparing the SIPOC (Supplier, Input, Process, Output, and Customer) diagram is to clarify which part of the process most influences the output of the rubber sole. This diagram will be very helpful for obtaining various important information in research for development and improvement. The flow process on SIPOC could be seen on Fig.3 as below.

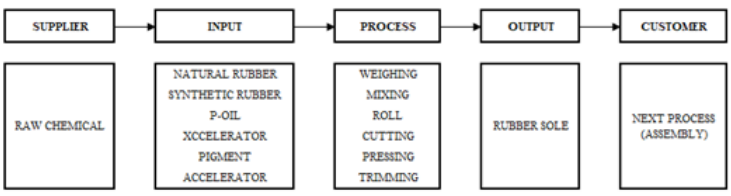

Figure 3. Diagram SIPOC

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In accordance with figure 3 above, it can be seen how the flow of a production process for making rubber soles so that it can present the process of production activities in the Bottom Press department.

1.Determination of CTQ (Critiqal To Quality)

At this stage critical to quality is determined as a characteristic that influences quality and direct relationship with customers and at this stage is also the process of defining critical to quality (CTQ) quality standard issues. The following can be seen in Figure 4. The types and percentage of rubber sole defects produced during the period June - December 2022.

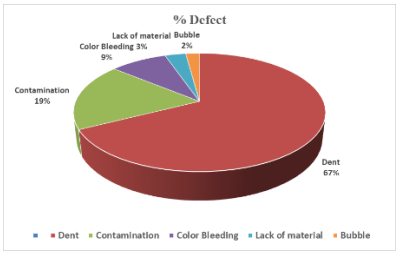

Figure 4. Type and Percentage of Rubber Sole defects

Information:

1. Dent: A type of defect that causes the surface of the rubber sole to not conform to predetermined quality standards.

2. Contamination: A type of defect that results in a dirty rubber sole surface due to dirt adhering to the rubber sole surface and difficult to clean.

3. Colour Bleeding: A type of defect caused by a colour transfer from 2 different colours on the rubber sole.

4. Lack of material: This type of defect is caused by insufficient preform material when placed in the mold prior to the pressing process.

5. Bubble: A type of defect caused by air trapped in the rubber sole during the pressing process.

6.2 Measure stage

At this stage, first of all, the calculation of defects per one million opportunities (DPMO) and Sigma Level will be carried out. The results of the calculation to find out the DPMO (Disability Per Million Opportunity) value and the Sigma level are shown in table 2 below.

Table 2. Data DPMO and Sigma level

Month	*Output (pasang)*	*Output (kg)*	*Waste (kg)*	*% Waste*	*CTQ Sigma*	*DPMO*	*Sigma*
June	1,106,687	376,274	19,062	5.1	5	9.643	3.84
July	1,036,547	352,426	18,294	5.2	5	9.869	3.84
Aug	902,312	306,786	14,834	4.8	5	9.224	3.86
Sept	813,404	276,557	16,461	6.0	5	11.235	3.79
Oct	843,327	286,731	15,830	5.5	5	10.464	3.81
Nov	893,931	303,937	17,161	5.6	5	10.688	3.81
Dec	871,942	296,460	10,006	3.4	5	6.529	3.98
Average	**924,021**	**314,167**	**15,950**	**5.1**	**5**	**9.665**	**3.85**

Next, to find out the most dominant defects to be repaired. Then, it will be using a Pareto chart. The following is the cumulative percentage calculation data as can be seen in table 3 as follow.

Table 3. Defect Rubber Sole Percentage

(Jun 2022 – December 2022)

No.	Defect type	Qty (prs)	% Defect	Cumulative %
1.	Dent	72,076	67.5	67.5
2.	Contamination	19,758	18.5	86.0
3.	Color Bleeding	9,315	8.7	94.7
4.	Lack of material	3,399	3.2	97.9
5.	Bubble	2,230	2.1	100.0
	Total	106,778		

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From table 3 it can be seen that the largest type of defect is Dent by 67.5% and the lowest type of defect is Bubble by 2.1%. From the target that the company wants to achieve, the number of defects produced has exceeded the company's target of 3%, so it is necessary to carry out repairs and controls to reduce the number of defects. One method that can be applied to overcome this problem is DMAIC (Define-Measure-Analyze-Improve-Control)

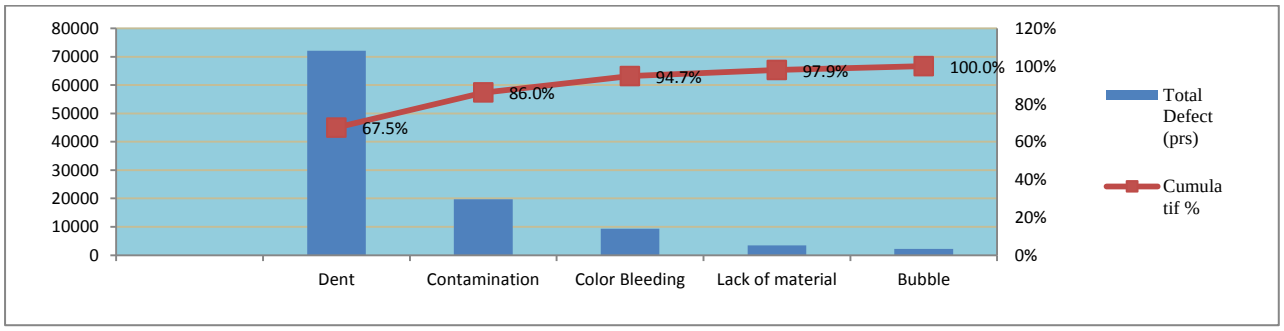

Figure 5. Diagram Pareto of defect Rubber Sole

According to the data shown in Figure 5.3, it shows that Dent defects are at the top with a number of defects of 72,076 prs (67.5%), the second largest defect is contamination with a number of defects of 19,758 prs (18.5%), the third is colour bleeding with a number of defects of 9,315 prs (8.7%), the fourth is lack of material with 3,399 prs (3.2%) defects and the 5th is bubble with 2,230 prs (2.1%) defects.

Based on these data, this research will focus on the largest number of defects, namely Dent.

Analyze Stage

The next stage in the DMAIC method is analyze, which at this stage is the process of analyzing the causes of rubber sole defects so that the root causes of dent defects can be identified using fishbone diagrams. The following is a Dent fishbone diagram as shown in figure 6 below.

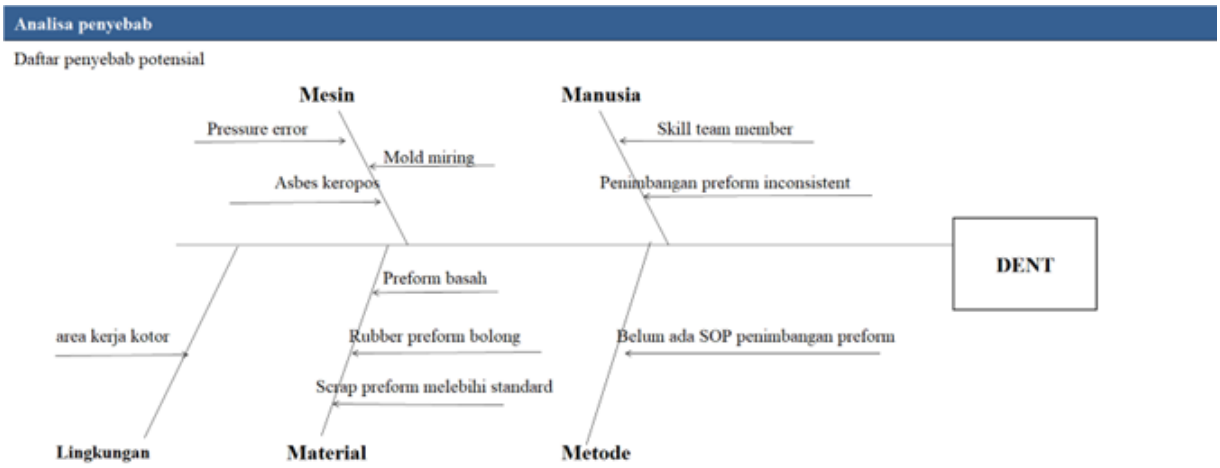

Figure 6. Fishbone Diagram

To find out the factors that cause Dent on rubber sole components. In accordance with Fig. 6 above, the main causes can be searched and categorized into 4 factors, namely:

Man

The main cause of defects from the human factor is the lack of team member skills and team members not following Standard Operating Procedures (SOP).

Method

The main cause of defects is caused by the absence of preform weighing SOPs. So that the team members do the weighing not according to the SOP.

Material

The main cause of defects is the preform material which is not solid.

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Machine

The main cause of the defect is due to the pressure machine error.

Environmental

The main cause of defects is caused by dirty team member work areas.

Improve stage

At this stage, corrective steps can be proposed and applied to the factors that have the most potential to cause rubber sole defects using the 5W+IH and FMEA methods.

Table 4. Suggestion for Improvement 5W+1H

No	Faktor	Kemungkinan Masalah	What	Why	Where	When	Who	How
1	Manusia	1. Skill operator 2. Penimbangan SOP inconsistent	Melakukan training	Agar skill operator meningkat dan penimbangan preform consistent	Plant Rubber sole	Jan-23	Supervisor	Memberikan training secara berkala
2	Metode	Belum ada SOP penimbangan	Membuat SOP	Agar operator bekerja mengikuti SOP	Plant Rubber sole	Jan-23	Supervisor	Mempersiapkan SOP
3	Material	1.Scrap preform melebihi standart	Melakukan kontrol terhadap proses	Agar defect rubber sole berkurang	Roll	Jan-23	Supervisor	Memastikan proses mengikuti SOP
		2. Rubber preform bolong bolong	Melakukan kontrol terhadap proses	Agar defect rubber sole berkurang	Roll	Jan-23	Supervisor	Memastikan proses mengikuti SOP
4	Mesin	Pressure mesin error	Memeriksa kondisi mesin sebelum digunakan	Agar defect rubber sole berkurang	Roll dan Hot Press	Jan-23	Supervisor	Perbaikan mesin
5	Lingkungan	Area kerja kotor	Melakukan 5S	Agar defect rubber sole berkurang	Roll dan Hot Press	Jan-23	Supervisor	Melakukan 5S sebelum bekerja

Table 5. FMEA (Failure Mode Effect Analysis)

Waste	Failure	S	Potential Failure Effect	O	Potential causes	D	Improvement suggestion	RPN
Defect	Rubber sole	10	Rubber sole defect	9	Less skill operator	7	Conduct regular training	630
					SOP not available	6	Ensuring SOP is available before production run	540
					Pessure machinery error	7	Checking machine condition before operation	630
					Operator's working area unclean	7	Conduct 5S activity on regular basis	630
Over Production		10	Higher production cost	9	Process less control	8	Ensuring working process follow SOP	720

Control Stage

After making improvements, follow the proposed improvements in table 4 and table 5. The following is the result of the improvements in table 6 below.

Table 6. Data Before Improvement

Month	*Output (pasang)*	*Output (kg)*	*Waste (kg)*	*% Waste*	*CTQ Sigma*	*DPMO*	*Sigma*
June	1,106,687	376,274	19,062	5.1	5	9.643	3.84
July	1,036,547	352,426	18,294	5.2	5	9.869	3.84
Aug	902,312	306,786	14,834	4.8	5	9.224	3.86
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Dec	871,942	296,460	10,006	3.4	5	6.529	3.98
Average	**924,021**	**314,167**	**15,950**	**5.1**	**5**	**9.665**	**3.85**

Table 7. Data After Improvement

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Month(2023)	*Output* (pasang)	*Output (kg)*	*Waste (kg)*	*% Waste*	*CTQ Sigma*	*DPMO*	*Sigma*
Jan	827,789	269,859	3,040	1.1	5	2.227	4.35
Feb	750,625	234,946	2,282	1.0	5	1.923	4.40
Mar	703,638	219,535	2,634	1.2	5	2.370	4.32
Average	**760,684**	**241,447**	**2,652**	**1.1**	**5**	**2.173**	**4.23**

Based on the data in table 6 and table 7, the percentage of waste before improvement is 5.1% and after improvement is 1.1%. It means that the company's target has been achieved. While the sigma level was before the improvement was 3.85 and after the improvement was 4.23.

4. CONCLUSION

Based on the results of data processing that has been carried out in the rubber sole production process, the conclusion is that the factors that cause waste rubber sole after analysis using a fishbone diagram are the human factor, namely the operator's skills are lacking, the machine factor, namely the press machine, often errors, the method factor. namely SOP for preform weighing does not yet exist, material factors, namely the use of scrap that is not according to standards and environmental factors, namely the operator's work area is dirty. The proposed improvements to reduce waste rubber sole are to provide regular training to operators, ensure the machine is in good condition before operation, SOP which have to apply by operators is available, operator works according to the SOP and working area all operator's is clean. The result of this research is rubber sole waste reduce to 1.1%. It means that the rubber sole waste has been achieved company's target.

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