Quality Control of Midsole Products Using Statistical Quality Control (SQC) and Failure Mode Effect Analysis (FMEA) Methods in PT. XYZ

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ARTICLE INFORMATION

ABSTRACT

PT. XYZ is a company engaged in the shoes industry. One such product is Midsole. In the Midsole production process, defects such as burning defects, tearing defects, bubble defects and dirty defects that affect quality are still found. The purpose of this study was to determine the proportion of defects that most often occur and the factors that cause defects and to provide suggestions for improving the quality of Midsole. The methods used are Statistical Quality Control (SQC) and Failure Mode Effect Analysis (FMEA). The SQC tools include check sheets, statistics, histograms, pareto charts, scatter diagrams, control charts, and fishbone diagrams. Then continue the FMEA analysis for suggestions for corrective action. Based on the results of research on Statistical Quality Control (SQC) it is known that the most dominant defects in midsole are burning (38%), then dirty (24,4%), bubble (20%), and tearing (17,6%)). Based on the results of research on Failure Mode Effect Analysis (FMEA) it is known that the highest cause of problems with RPN 343 is Mold Release Agent spraying is uneven. Suggestions for improvement that can be proposed namely. Conduct training for workers on how to spray MRA according to stamdart and determine the rest time limit so that the injection engine does not overheat.

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1. INTRODUCTION

The development of the industry at this time, there has been an evolution in which competition in the industrial world led to developments in the industrial world supporting factors for success in development in Indonesia, with the tight competition that will be faced in a company must be better prepared in the competition. With the existence of a quality control and statistical methods used is expected to be able to give an impact significantly to the quality of the final product which will meet the standards of the company and also can be a cost efficiency for the company. The operational

activities of a company can run effectively and efficiently if the company implements quality control to reduce product failures or damages, aiming to achieve the required quality standards (Meldayanoor et al., 2018).

PT. XYZ located in Jepara City is one of the companies that engaged in the shoe industry where this company produces one the components of the shoe, namely the midsole, as one of the work units of PT. XYZ processes compound raw materials into midsole as its main product. Therefore in the production process PT. XYZ always tries to provide a product that quality and the best price to be given to manufacturers of finished shoes. However, as time goes by, market demand and competition will increase increases, companies will be required to compete and must have advantages competitive, by producing quality products. During the manufacturing process there are still many defects including burning, tearing, bubbles and dirty which had a significant effect causing defects to exceed the company's standard limits. And of all the defects that have been observed, it is known that defects in the midsole production process have a total defect of 9%.Therefore, in accordance with the discussion above, the researcher applies the SQC method to find out the reasons why product defects occur and FMEA analysis to provide suggestions for improvements to the quality control of midsole production at PT. XYZ.

Based on the problems that occur, find out the percentage of product defects, as well as the causes of this midsole product defect. So that it is hoped that steps can be determined that will resolve what is the cause of a defect when carrying out the production process at PT. XYZ. With this research, it is hoped that it can help and overcome problems that occur at PT. XYZ and can provide the right solution for the problem of quality control of midsole production.

2. LITERATURE REVIEW

This chapter discusses the theories that support and play a crucial role in supporting the research implementation. These include theories on Quality, Quality Control, Statistical Quality Control (SQC), and Failure Mode

Effect Analysis (FMEA). These theories will serve as the researcher's guide in conducting the study. Quality is one of the most important consumer decision factors in choosing a product or service, and consumers are referred to whether individuals, industrial organizations, retail stores, banks or financial institutions, or military defense programs. So understanding and improving this quality is a key factor in leading to business success, growth, and increasing competitiveness. Therefore, understanding and improving this quality is a fundamental factor for business competitiveness (Montgomery,2013). Quality control activities are basically a whole series of activities that seek to achieve "fitness for use" conditions regardless of where these activities will be carried out, namely starting from the time the product is designed, processed, until it is finished and distributed to consumers. So quality control is a tool used to monitor operational activities and ensure how actual performance is in accordance with what has been planned by a company. Furthermore, the notion of quality control in its overall meaning is an effort to maintain the quality of a product that has been produced by a company or agency, so that the product can comply with the desired specifications based on company policy (IS Haryanto, 2019).

Statistical Quality Control or statistical quality control is an important application of statistical techniques in the manufacturing industry. Typically, the manufacturing industry receives raw materials from vendors. Therefore, it is important to inspect the raw materials before making a decision on whether to accept them or not. It is almost impossible to inspect every item of raw material. Thus, a few items (samples) are randomly selected from a large population of raw materials and individually inspected before making a decision on whether the entire population is acceptable or meets the standards (Selvamuthu, 2018). Failure Mode and Effect Analysis (FMEA) is a systematic approach using a table method to assist the thought process in identifying potential failure modes and their effects. FMEA is a technique for evaluating the level of reliability of a system in determining the effects of failure of the system. These failures are classified based on the effect

they have on the success of a mission of a system (Erwindasari, 2020).

FMEA is a tool that systematically identifies the consequences or consequences of system or process failures and reduces or eliminates the opportunities for such failures to occur. FMEA can be used to analyze the causes of failure related to equipment reliability (Febriana, 2020). FMEA is an important technique used to identify and eliminate known failures or have the potential to improve the reliability and security of complex systems and is intended to provide critical information for making decisions in risk management (Akhyar, 2020). In FMEA, component failures are linked to risk events, while each failure can become the object of detailed failure analysis and corrective action planning (Aboutaleb et al., 2019). Due to innovation in implementing and managing projects, effective use of Failure Modes and Effects Analysis (FMEA) technique has been proposed (Bahrami et al., 2012).

FMEA aims to delight and satisfy customers by preventing possible failures at all levels from product conception to delivery completion to ensure quality improvement and product reliability delivered on time to users (Belu et al. 2013). The relationship between failure modes and effect analysis and statistical quality control lies in the fact that failure modes and effect analysis identify critical sources of defects in quality problems by conducting risk assessments, which can determine the priority of failure mode risks.. Based on the known risk priorities, actions can be developed and formulated to reduce risks, thereby identifying which recommended actions are useful in preventing defects (Dewi, 2019). midsole is a cushion on the shoe that provides protection for the foot. There are several types of Midsole, one of which is EVA. EVA (Ethyl Vinyl Acetate) is a soft and flexible midsole, suitable for sports or outdoor shoes that require comfort. The midsole is located in the middle between the upper and the outsole, and is the most important shoe component. Made from a breathable material, its function is to protect the foot from impact, providing cushioning, bounce and support. Detection (DET) refers to the measurement of the ability to detect or control potential failures that may occur (Rinoza et al., 2021). Detection (D) is an assessment of the likelihood that a tool

can detect potential causes of a failure. Detection serves as a preventive measure in the production process and reduces the failure rate in the production process (Alfianto, 2019). In the evaluation of detection ratings, a scale of 1 to 10 is used. A value of 1 indicates a very high reliability in detecting a process failure, approaching 100%. On the other hand, a value of 10 indicates a very low reliability in detecting a process failure, less than 90% (Taufik, 2021). The literature review highlights a lack of standardized methodologies for assessing the impact of SQC on FMEA. Future research could focus on developing and validating robust methodologies that offer more accurate and reliable measurements in this context.

3. RESEARCH METHOD

In this research, the Statistical Quality Control method and Failure Mode and Effect Analysis are used. The following flow to solve this problem can be seen in Figure 1.
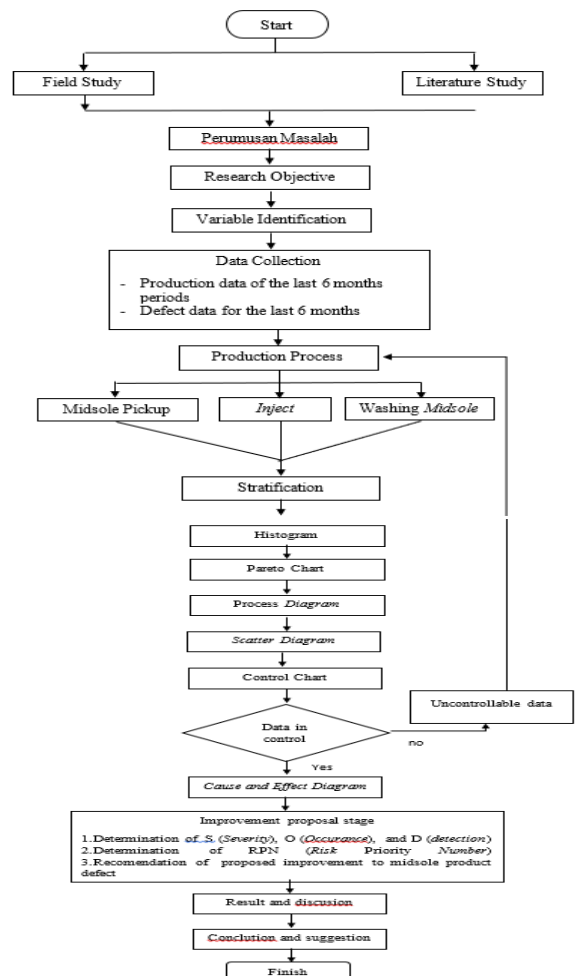

Fig. 1. Research stages

Based on the Fig. 1, the research stages are a series of steps that must be taken in a research process to achieve predetermined goals. The description of the sequence of solving an event above is to conduct a survey of existing problems to determine the formulation of problems and research objectives, then identify the dependent variable (Quality Defects of midsole products at PT. XYZ) and the independent variable (types of midsole defects). Then collect research data including primary data from interviews with the QC division and secondary data in the form of midsole production data. Next, process the data with the SQC method with a seven tools approach (check sheet, stratification, histogram, pareto diagram, scatter diagram, control chart and cause and effect diagram), then make an improvement suggestion with FMEA analysis

based on the calculation of the RPN value of the multiplication of Severity (S), Occurance (O), and Detection (D). These stages form a systematic framework and help researchers to organize and direct the research process clearly and purposefully

4. RESULT AND DISCUSSION

In the calculation using the SQC method and improvement recommendations using the FMEA method with the following results:

4.1 Stratification
Startification is the stage for grouping data in groups that have the same characteristics. The results of the startification according to the check sheet are shown in Table 1.

Table 1. Stratification

No	Month	Total Production	Defect Type				Total
			Pest	**Color**	**Pod**	**Mechanical**	
1	August	310,523	13,738	5,300	9,126	6,824	34,988
2	September	344,263	9,179	4,101	5,797	8,765	27,842
3	October	321,968	13,685	4,266	6,691	9,984	34,626
4	November	317,752	10,426	8,261	7,070	5,856	31,613
5	December	333,369	12,049	2,452	3,935	4,862	23,298
6	January	354,538	8,228	6,795	2,839	7,025	24,887
	Total	**1,982,413**	**67,305**	**31,175**	**35,458**	**43,316**	**177,254**

(Source : production data PT.XYZ, 2023)

In Table 2. Stratification of the data used is the company's internal data or production data of PT XYZ for the last 6 months, where in the stratification table can separate data into subgroups based on certain variables such as, total production in each month, types of defects that are often found, and total defects each month. By using stratification, it can take targeted corrective actions and improve the overall quality of the product or process.

4.2 Histogram
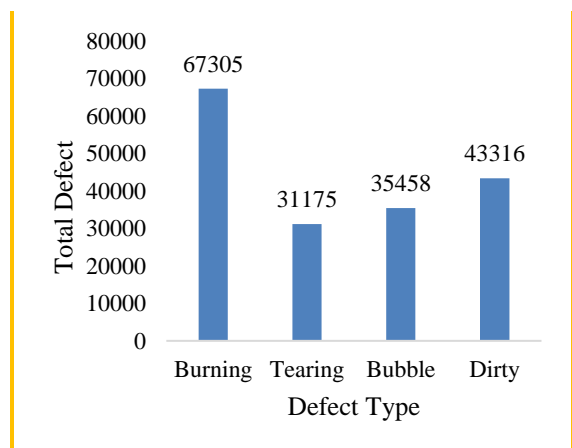
Fig. 2. Histogram
(Source : processed data, 2023)

Based on the histogram figure, it can be seen that the interval order of each type of defect that occurs the most is known to be 67.305 pieces of

pest burning, then tearing defects with a total defect of 31,117 pieces, then bubble defects with a total defect of 35,458 pieces and dirty defects with a total defect of 43,316 pieces.

4.3 Pareto Chart
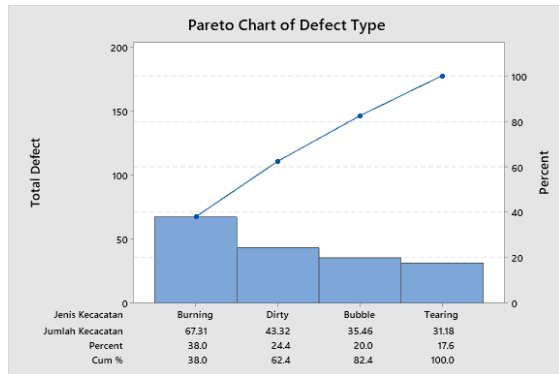
Fig. 3. Pareto chart
(Source : processed data, 2023)

Based on the Pareto diagram, it can be seen that the most dominant type of defect seen from the cumulative percentage is burning defects with a percentage of (38%), followed by dirty defects with a percentage of (24.4%), then bubble defects with a percentage of (20%), and dirty defects with a percentage of (17.6%).
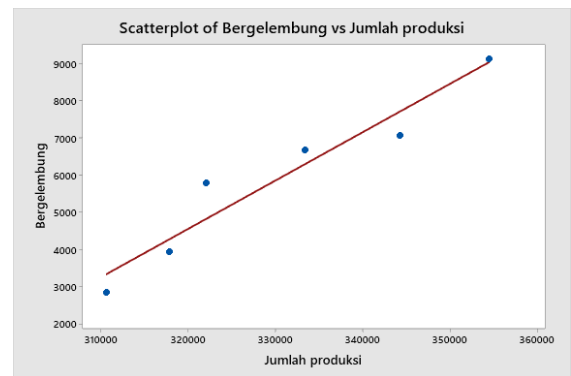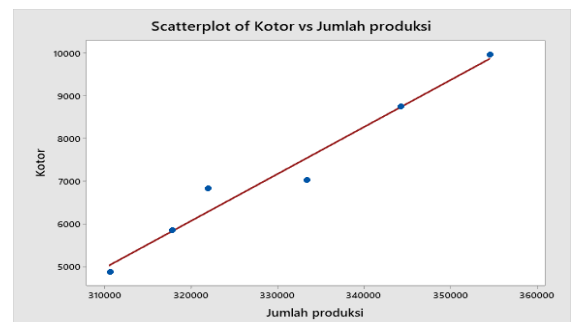
4.4 Scatter Diagram
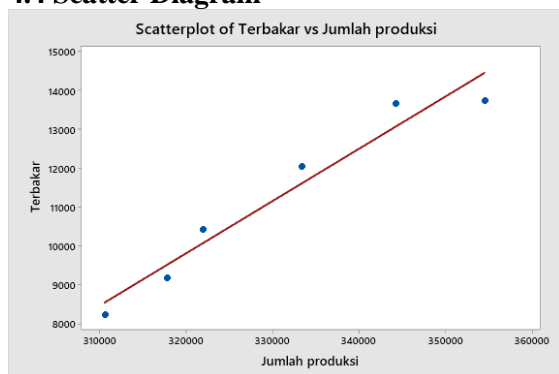
Fig. 4. Scatterplot of pest defect vs total production
(Source : processed data, 2023)
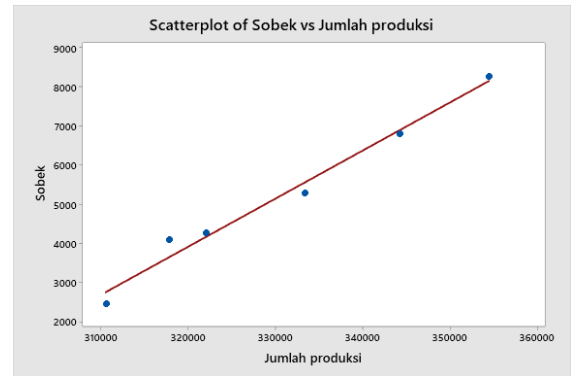
**Fig. 5**. Scatterplot of color defect vs total production (Source : processed data, 2023)

Fig. 6. Scatterplot of Pod Defect vs Total Production (Source : processed data, 2023)
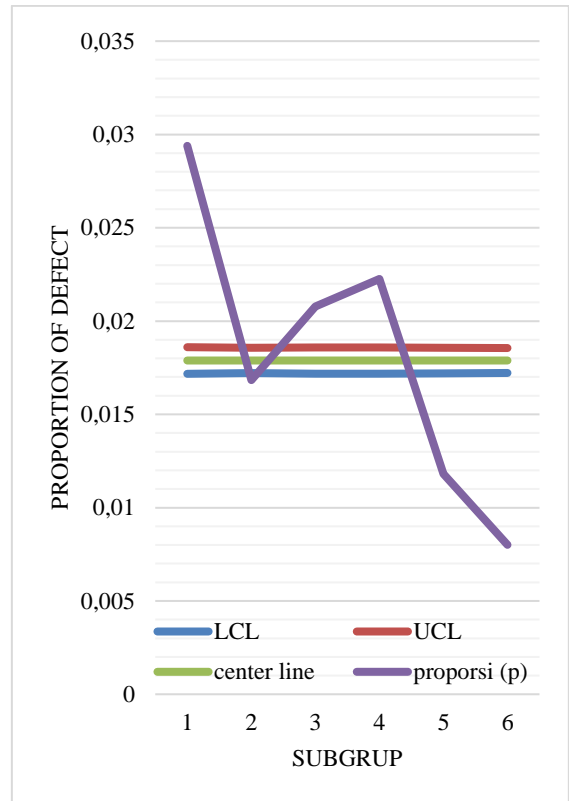

Fig. 7. Scatterplot of mechanical defect vs total production (Source : processed data, 2023)

Based on the scatter diagram above, the four types of defects, namely burning defects, tearing defects, bubble defects and dirty defects on midsole production show the results that of the four types of defects where the increasing variable X is followed by an increase in variable Y, meaning that when there is an increase in production, there is an increase in the number of defects as well and vice versa.
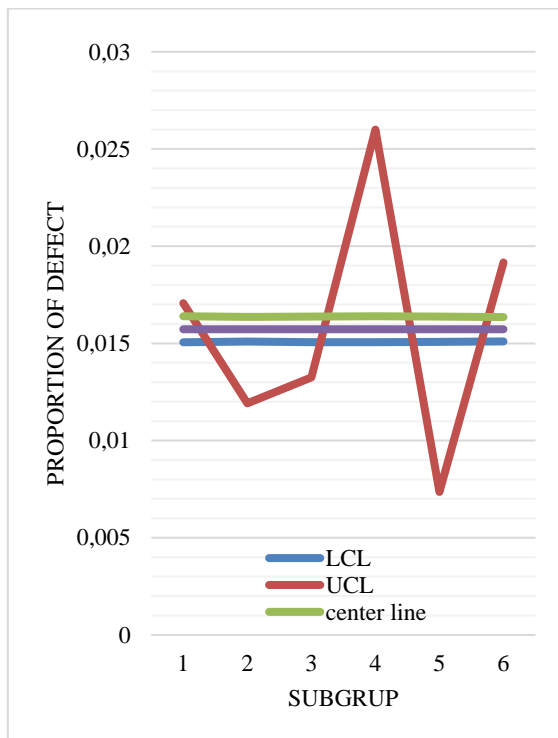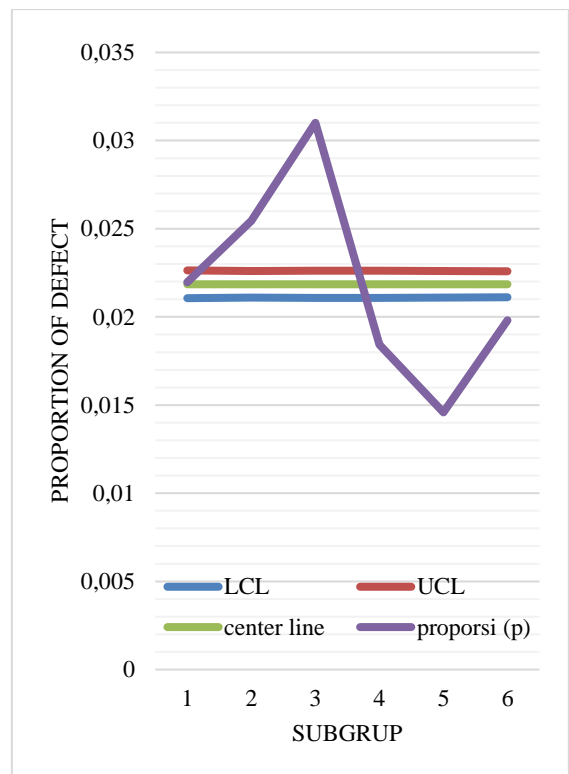
4.5 Control Chart
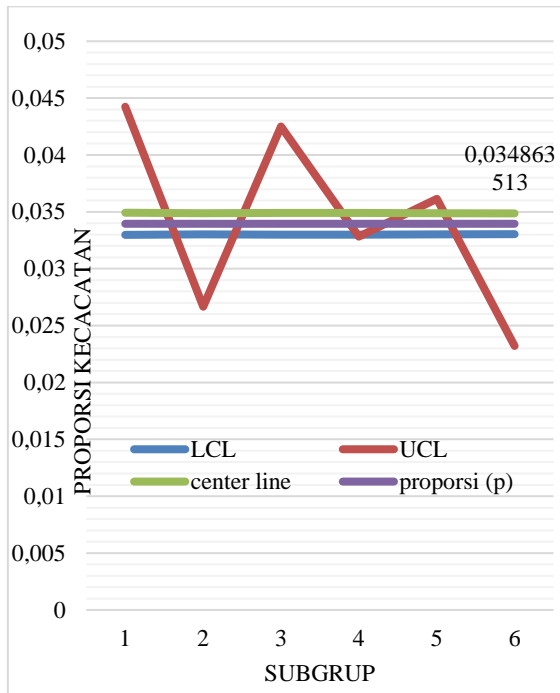
Fig. 8. P-Chart pest defect
(Source : processed data, 2023)

**Fig. 9**. P-Chart color defect
(Source : processed data, 2023)

**Fig. 10**. P-Chart pod defect
(Source : processed data, 2023)

Fig. 11. P-Chart mechanical defect
(Source : processed data, 2023)

From the data processing that has been carried out, the data is still within the upper control limit and lower control limit. Since there is no data out of the control limits, it can be concluded that the percentage of defective products in midsole products is within the control limits.
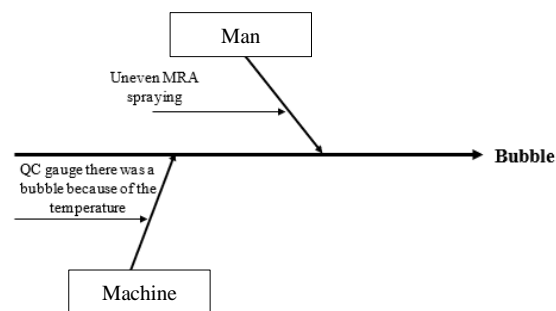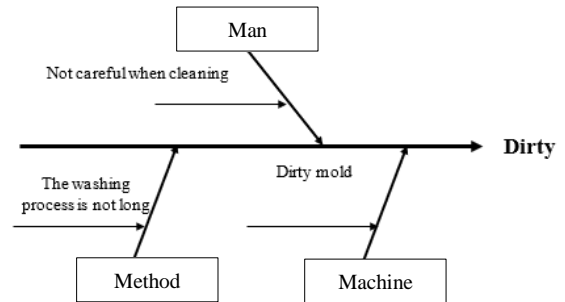
4.6 Cause and Effect
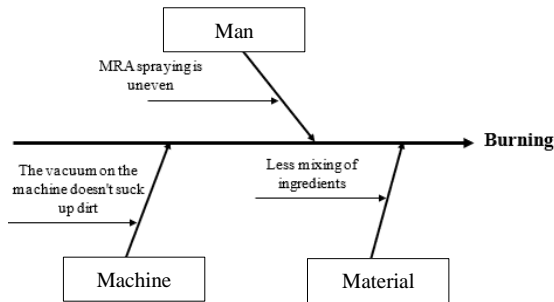
Fig. 12. Cause and effect diagram burning
(Source : processed data, 2023)
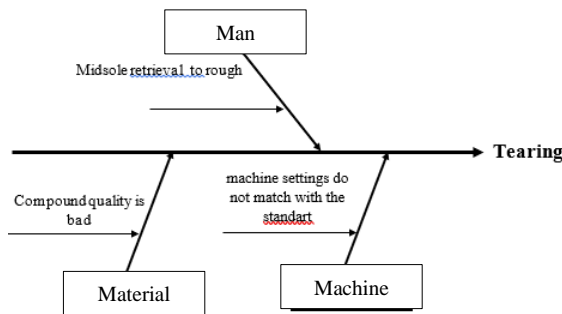
Fig. 13. Cause and effect diagram color
(Source : processed data, 2023)

Fig. 14. Cause and effect diagram pod
(Source : processed data, 2023)

Fig. 15. Cause and effect diagram mechanical
(Source : processed data, 2023)

From Fig.12-15 the cause and effect diagram above is the root cause of each type of defect in the midsole products studied, namely there are burning defects, tearing defects, bubble defects and dirty defects. Where the root cause data of the cause and effect diagram is obtained through several sources, namely, first by making direct observations at the company or in the production process by observing the process directly, and identifying the factors that are the root causes of defects. Second, it is obtained from operational data such as production records, inspection reports, and product failure data that provide information about the problems that occur. The third is obtained from qualitative data collection such as interviews with superiors or employees, to gain their insights and perspectives and quantitative data through measurement and statistical analysis provides objective information about variables that affect quality.

Based on the cause and effect diagram, it can be seen the causes of defects in each factor. For burning defects, the cause of the problem is the uneven spraying of MRA (Mold Release Agent), the vacuum on the machine does not suck up dirt and the mixing of inappropriate ingredients. For tearing defects, the cause of the problem is rough picking of the midsole, poor quality compound and inappropriate machine settings. For bubble defects, the cause of the problem is the uneven spraying of MRA (Mold Release Agent) and differences in temperature during the quality control gauge. For dirty defects, the cause of the problem is not being careful when cleaning the mold, the washing process is not taking long, and mold or mold dirt.

4.7 Failure Mode Effect Analysis (FMEA)

Failure Mode and Effect Analysis is a reliability analysis method intended to identify failures, which have the consequence of affecting the functioning of the system within the boundaries of a given application, thus allowing priorities for action to be set (Putri, 2021). Traditionally, FMEA is used to conduct risk analysis through the Risk Priority Number (RPN), which is derived from a combination of Occurrence (O), Severity (S) and Detection (D) (Aprianto et al., 2021.

Table 2. FMEA assessment

Potential Failure Mode	Potential Effect Of Failure	Potential Cause	Current Control	S	O	D	RPN
Burning	Burning attacks on midsole can It will reduce the aesthetic value because it looks visually unfavorable and will reduce consumer interest in the product .	MRA spraying was uneven	Conduct training for workers on how to spray MRA according to SOP and Determine the rest time limit so that the injection engine does not overheat	7	7	7	343
Bubble	it will reduce the aesthetic value because it looks visually unfavorable and makes the painting process take longer.	MRA spraying was uneven	Providing training to workers to make them more skilled and also providing direction to workers before the production process runs and Carry out stricter supervision so that employee carelessness does not occur repeated.	5	7	7	245
Dirty	It will reduce the aesthetic value because it looks visually unfavorable and makes the painting process take longer .	Not careful when cleaning the mold	Conduct training for workers on how to spray MRA according to SOP and Determine the rest time limit so that the injection engine does not overheat .	6	5	4	120
Tearing	It Will add to the greater tear when exposed to the load and make the midsole quickly damaged**.**	Rough take on midsole	Briefing workers on how to take the midsole correctly before doing work.	3	6	5	90

(Source: result focus group discussion with experts, 2023)

Based on the results of the calculation of the RPN (Risk Priority Number) value, it can be seen that the process failures that cause defects, the causes of disability (Potential causes) are then sorted from the highest to the lowest RPN value and then given recommendations for improving each cause. The order of improvement recommendations based on RPN can be seen in table 4.

Table 3. Recommendations for improvement based on RPN ranking

Priority	Potential Failure Mode	Potential Cause	RPN	Recommendation
1	Burning	MRA spraying was uneven	343	Providing training to workers to make them more skilled and also providing direction to workers before the production process runs and Carry out stricter supervision so that employee carelessness does not occur repeated
2	Bubble	MRA spraying was uneven	245	Providing training to workers to make them more skilled and also providing direction to workers before the production process runs and Carry out stricter supervision so that employee carelessness does not occur repeated.
3	Burning	Vacuum on the machine does not suck dirt	168	Machine servicing regularly. Check and replace vacuum regularly .

(Source: result focus group discussion with experts, 2023)

Based on the results of the RPN calculation for FMEA midsole products, several risks are obtained that have the highest priority level for making improvements to minimize the possibility of errors. The calculation of the highest RPN value is 343 from the type of burning defect with the potential cause of MRA spraying was uneven with proposed recommendations is providing training to workers to make them more skilled and also providing direction to workers before the production process runs and Carry out stricter supervision so that employee carelessness does not occur repeated, the second order is the RPN value of 245 from the type of bubble defect with the potential cause of MRA spraying was uneven with proposed recommendations is providing training to workers to make them more skilled and also providing direction to workers before the production process runs and Carry out stricter supervision so that employee carelessness does not occur repeated. The third order is the RPN value of 168 from the type of burning defect with the potential cause Vacuum on the machine does not suck dirt with the proposal recommendations is to servicing machine regularly and check and replace vacuum regularly.

After taking action for the 3 priority rankings (pests, pods, mechanical), where the number of defects has decreased and is under control within the standard defect limit set by the

company which is 5% . Previously, of all the defects that have been observed, it is known that defects in the midsole production process have a total defect of 9%, which is outside the predetermined standard limit of 5%.

Research results this study with the previous research is in this research show that implementing SQC can assist in detecting quality deviations earlier in the production process, enabling rapid corrective action. Some of the control charts used, such as pareto charts and control charts, help in monitoring the averages and variations of the production process. Additionally, FMEA assists in identifying potentially detrimental failure modes, allowing production teams to take appropriate preventative measures.

The relationship between SQC and FMEA lies in the way they complement each other in solving midsole quality control problems. SQC is used to control quality during the midsole production process, while FMEA is used to identify and address potential failures in the design or production process of midsole. Here is a further explanation of the relationship of each tool in midsole quality control problem solving:

SQC (Statistical Quality Control):
1. Data collection, in the SQC method, data related to midsole quality such as size,

number of midsole burning, etc. are collected regularly during the production process.
2. Statistical Analysis, the collected data is analyzed using statistical techniques such as startification, check sheets, histograms, pareto, scatter diagrams or map diagrams to identify significant patterns, deviations or changes in midsole quality.
3. Action Taking, if the statistical analysis indicates any deviation from the set quality standards, corrective measures such as machine adjustments, process parameter changes, or operator training can be taken to control midsole quality

FMEA (Failure Mode and Effects Analysis):
1. Identify Potential Failures, in the FMEA method, the team comes together to identify various failure modes that may occur during the midsole production process, for example, non-standard burning count, tearing defect, bubble defect and dirty defects.
2. Effect and Risk Evaluation, once the failure modes are identified, analyzes the potential effects of each of these failures on midsole quality and the impact on customers or consumers. Risk levels are assigned based on a combination of failure severity, occurrence and detection.
3. Corrective Action, after analyzing the risk of failure, proposes and implements appropriate corrective actions to reduce the risk of the failure.
4. SQC and FMEA complement each other in optimizing quality control of midsole products.
5. SQC helps in controlling quality during the production process, while FMEA helps in identifying and addressing potential failures through risk analysis and appropriate corrective actions

5. CONCLUSION
Based on the results of data processing with statistical quality control (SQC), it is known that the highest defect with Pareto digram is the most dominant type of defect is burning defect of 67,305 with a percentage of (38%), followed by dirty defect of 43,316 with a percentage of (24.4%), then bubble defect of 35,458 with a percentage of (20%), and tearing defect of

31,175 with a percentage of (17.6%). Factors causing burning defects are The MRA spraying was uneven Vacuum on the machine does not suck dirt, Inappropriate mixing of ingredients, poor worker training, rarely service the machine, lack of direction of workers in spraying, lack of inspection on the vacuum machine. Based on the results of the RPN calculation for FMEA of midsole products, several risks are obtained that have the highest priority level for making improvements to minimize the possibility of errors. The calculation of the highest RPN value is 343 the type of defect burning caused by the uneven spraying of MRA (Mold Release Agent) due to human factors. Recommendations for improvements that can be made are by providing training to workers so they are skilled in spraying, and setting rest time limits so that the injection machine does not overheat. The suggestion to further research is with the SQC and FMEA methods, it is hoped that the company can reconsider implementing the recommendations for improvements that have been given in order to minimize any defects that occur in the product.

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