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Quality Control Analysis of Sickle Products Using Statistical Quality Control (SQC) and Failure Mode and Effects Analysis (FMEA)

Fatikhul Arief[1]✉, Moh. jufriyanto [2]

[1, 2] Industrial Engineering Study Program, Faculty of Engineering, Universitas Muhammadiyah Gresik, Indonesia

✉ **Corresponding Author :** Fatikhul Arief (e-mail: fatikhularief@gmail.com)

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ABSTRACT

PT. ABC is a manufacturing company that produces agricultural and plantation tools, with one of its superior products being sickles. The main problem faced by the company lies in the high number of defective products in sickle, so this study was conducted with the aim of minimizing defects in these products. This study applied the Statistical Quality Control (SQC) method as a quality management approach to control product quality through the integration of the Failure Mode and Effect Analysis (FMEA) and SQC methods. Primary data was obtained through interviews to identify the causes of product defects, while secondary data was obtained from production reports and the company's defect count. Based on the results of the analysis using a pareto diagram, it was found that 88% of quality problems were caused by cracks in the sickle blades. Furthermore, through Risk Priority Number (RPN) analysis, it was found that the main contributing factor was human error, namely operators who did not understand the applicable standard operating procedures (SOP), with an RPN value of 315. This finding indicates that crack defects are a dominant factor affecting product quality.

INTRODUCTION

In the modern era, competition among manufacturers is increasingly fierce in their efforts to introduce products to attract consumer interest. Quality control is an important strategy implemented by companies to increase competitiveness in the global market.(Dewi & Yannimar, 2023). To ensure quality, quality control is carried out through systematic and structured stages to ensure that each product meets standards, is free from defects, and complies with specified specifications.(Aini & Sukanta, 2024)

Product quality is very important to consider, because product quality greatly affects consumer satisfaction with the products produced.(Oktaviani et al., 2022). Good quality products can increase customer satisfaction and minimize the potential for complaints after the product is used.(Nurdinia et al., 2021). Product quality is considered acceptable if it is comparable to the costs incurred and is able to satisfy users.(Haryono & Sumiati, 2023). The main objective of quality control is to maintain and uphold product quality standards in accordance with company management requirements.(Wardah et al., 2022). Good quality control needs to be implemented through the application of quality improvement methods aimed at reducing the percentage of defective products, so that the products produced are of high quality and able to satisfy consumers.(Azis & Vikaliana, 2023). One of the main objectives of Quality control is carried out to minimize the number of product defects. even to the point of achieving zero defects.(Levia, 2023)

PT. ABC is a manufacturing company engaged in the production of agricultural equipment, with one of its main products being sickles or egrek. A sickle is a crescent-shaped tool used to harvest oil palm fruits at a height of around 4–5 meters, serving to efficiently cut oil palm bunches and fronds. The issue faced by PT. ABC is the increasing number of defective products, particularly in the sickle product line, which is causing losses for the company. Based on production data for April 2025, the product defect rate reached 13.45% of total production output. Defective products are those produced as a result of manufacturing processes that fail to meet the quality criteria established by the company.(Ismayanti et al., 2024). Based on this background, the objective of this research focuses on reducing the occurrence of defects in sickle products and implement improvement efforts by analyzing the underlying causes using Statistical Quality Control (SQC) and Failure Mode and Effect Analysis (FMEA) methods.

RESEARCH METHODS

The research was conducted over the period of May to June 2025 with a focus on the finishing and Outgoing Good Inspection (OGI) departments at PT. ABC. The data used was quantitative, consisting of production output and defect data for sickle products during April 2025. The selection of the April 2025 period was based on the consideration that during that month, the company experienced a significant increase in production volume, so the data obtained was considered to represent the actual conditions of the production process. The amount of data analyzed consisted of a total of 2290 units of products produced during that period, with 308 units identified as defective. This research includes several stages, including data collection, data processing, and analysis to solve existing problems. This study uses two main methods, namely Statistical Quality Control (SQC) and Failure Mode and Effect Analysis (FMEA) with the aim of identifying the causes of defects and formulating efforts to reduce the number of defects in sickle products.

Statistical Quality Control

Statistical Quality Control (SQC) is a statistical approach applied to monitor and control the quality of products at each stage of production. This method is designed to maintain consistent quality while minimizing production costs.(Oktavia & Herwanto, 2021). Statistical Quality Control (SQC) methods are implemented to detect errors across all stages of production, especially those that could potentially cause defects or damage to products.(Nazia et al., 2023). To resolve the issues that arise, Several tools are used in quality control, including check sheets, control charts, Pareto diagrams, and fishbone diagrams.(Nurdinia et al., 2021)

1. A checksheet is a tool that functions to record total production output and the number of units that have been damaged. This instrument is usually arranged in a simple table to facilitate data recording and systematic analysis..(Pratama & Rochmoeljati, 2022)
2. A control chart is a graph that serves as a tool for monitoring production process stability through graph, the process can be observed to see if it is still within the specified control limits.(Margareta & Nugroho, 2023). Data processing is carried out using a P-Chart. P-Chart analysis is used to determine the proportion or percentage of products that are damaged in production, so that quality defects can be identified before the products are marketed.(Putra et al., 2022)
   - Calculating the percentage of defects

$$P = \frac{np}{n}$$

np : number of defects
n : number checked

   - Calculating the central line (CL)

$$CL = \bar{p} = \frac{\sum np}{\sum n}$$

$\bar{p}$: Average defect in sickle
$\sum$np : total defective sickles
$\sum$n : total sickles inspected

- Calculating the *upper control limit* (UCL)

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}\,(1-\bar{p})}{n}}$$

$\bar{p}$: Average defect rate of sickle products
n : Production output

- Calculating the *lower control limit* (LCL)

$$UCL = \bar{p} - 3\sqrt{\frac{\bar{p}\,(1-\bar{p})}{n}}$$

$\bar{p}$: Average defect rate of sickle products
n : Production output

3. Pareto diagrams are used to identify the most dominant problems and help focus improvements on the most urgent aspects, so that quality improvement efforts can be carried out more effectively.(Simarmata et al., 2023)

   Percentage of Defects = $\frac{\text{number of types of defects}}{\text{Total defects}}$ X 100%
4. Fishbone diagrams serve to identify the main factors that affect quality and cause problems with products.(Safrizal & Zulaikha, 2021)

Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effect Analysis (FMEA) is a method used to analyze, identify, and prioritize potential failures in products, processes, and systems, as well as determining the necessary preventive measures.(Suyatno et al., 2025). The FMEA method has several advantages, including cost savings, a structured approach, and a focus on improving potential causes of problems.(Muvidah et al., 2023). The purpose of applying this method is to obtain the highest Risk Priority Number (RPN) value, which is prioritized in the preparation of improvement proposals. Thus, improvement efforts can be focused on factors that have the most significant risk level for process failure.(Syahrullah et al., 2021). The Risk Priority Number (RPN) value is obtained from the multiplication of Severity, Occurrence, and Detection.(Akbar et al., 2025)

1. Severity is a description of the extent of the consequences that arise when a failure occurs in the failure effect.(Muvidah et al., 2023)
2. Occurrence is an assessment of the probability or frequency of the cause of failure, so that the failure mode that causes a certain impact on the system can be identified.(Aldi et al., 2023)
3. Detection is an assessment related to the ability of controls to detect specific types of failures.(Faisal & Setiafindari, 2024)

Integration between Failure Mode and Effects Analysis (FMEA) and Statistical Quality Control (SQC)

The integration between Failure Modes and Effect Analysis (FMEA) and Statistical Quality Control is that FMEA identifies critical sources of quality defects through risk assessment, so that risk priorities can be determined for failure modes. Through this risk assessment, the severity of the effects of a failure mode, the frequency of failure occurrence, and the control capabilities used to detect the failure mode can be determined.(Haryono & Sumiati, 2023).

RESULTS AND DISCUSSION

Statistical Quality Control (SQC)

1. *Checksheet*

   The starting point of quality control is to prepare a checklist to facilitate the collection, grouping, and analysis of product data and defect types.

Table 1 Table Checksheet

Date	Production Output	Defect					Total Defects
		Crack	Thin Back	Wide-	Curve -	Visual Ng	
9 Apr 2025	112	1	1	3	0	0	5
10 Apr 2025	170	5	2	0	0	0	7
11 Apr 2025	188	13	1	0	1	2	17
14 Apr 2025	256	38	0	0	0	0	38
15 Apr 2025	186	68	0	0	0	0	68
16 Apr 2025	71	3	2	0	0	0	5
17 Apr 2025	130	11	0	0	1	0	12
19 Apr 2025	120	10	4	0	0	0	14
21 Apr 2025	177	41	4	0	0	0	45
22 Apr 2025	186	34	13	0	0	0	47
25 Apr 2025	204	24	0	0	2	0	26
26 Apr 2025	122	7	0	0	1	0	8
28 Apr 2025	184	10	0	0	0	0	10
29 Apr 2025	184	6	0	0	0	0	6
Total	2290	271	27	3	5	2	308

Based on the checklist, there are five categories of defects in sickle products, namely crack defects, thin back defects, width defects, curve defects, and visual NG defects. There were 271 units with crack defects, 27 units with thin back defects, 3 units with wide- defects, 5 units with curve- defects, and 2 units with visual NG defects, with a total production of 2290 units. These results indicate that quality problems in sickle products occur more frequently due to cracks in the sickle blade, which are most likely caused by operators' lack of understanding of the heat treatment process or errors that occur during the finishing stage.

2. *Control Chart*
   The next step is to perform calculations using a P-Chart control chart, which aims to determine whether the proportion of defects on the chart is still within control limits or not. If data is found to be outside the control limits, corrective action can be taken immediately.

Table 2 Table Control Chart

Date	Production Output	Total defects	Proportion	CL	UCL	LCL
9 Apr 2025	112	5	0,045	0,134	0,231	0,038
10 Apr 2025	170	7	0,041	0,134	0,213	0,056
11 Apr 2025	188	17	0,090	0,134	0,209	0,060
14 Apr 2025	256	38	0,148	0,134	0,198	0,071
15 Apr 2025	186	68	0,366	0,134	0,210	0,059
16 Apr 2025	71	5	0,070	0,134	0,256	0,013
17 Apr 2025	130	12	0,092	0,134	0,224	0,045
19 Apr 2025	120	14	0,117	0,134	0,228	0,041
21 Apr 2025	177	45	0,254	0,134	0,211	0,058
22 Apr 2025	186	47	0,253	0,134	0,210	0,059
25 Apr 2025	204	26	0,127	0,134	0,206	0,063
26 Apr 2025	122	8	0,066	0,134	0,227	0,042
28 Apr 2025	184	10	0,054	0,134	0,210	0,059
29 Apr 2025	184	6	0,033	0,134	0,210	0,059
Total	2290	308				

The following is a graph generated from the processed data.

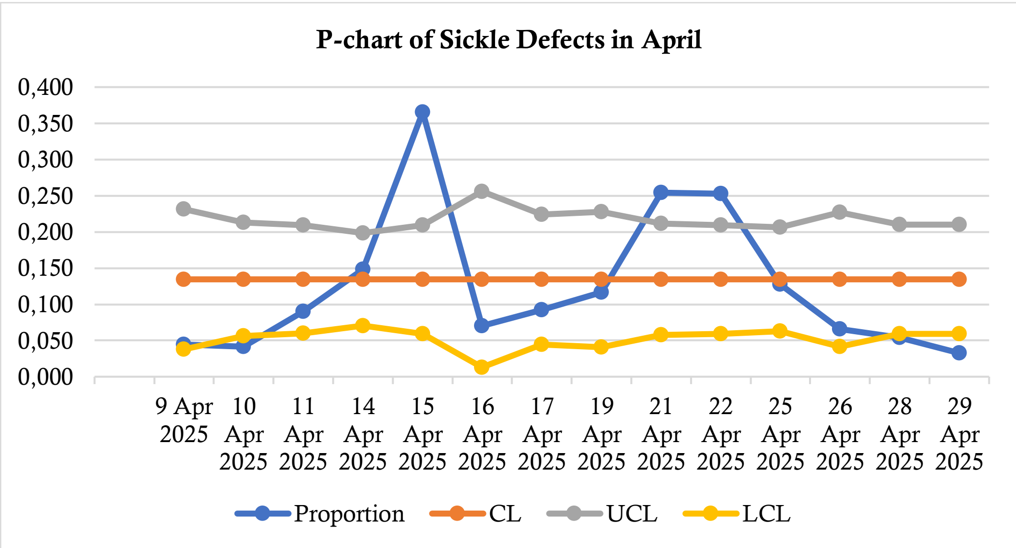

Figure 1 P-chart of Sickle Defect

Based on the graph in the control chart illustrated above, it can be seen that there are periods that exceed the quality control limits (out of control), namely on April 10, 15, 21, 22, 28, and 29, 2025. Therefore, corrective measures need to be taken. This condition indicates that the production process is not yet fully stable and still experiences variations caused by specific factors (assignable causes), thus requiring improvement efforts.

3. Pareto Diagram
   After creating the control chart, the next step is to compile a pareto diagram to identify and rank defect types based on their dominance level, from highest to lowest, along with their percentages.. Based on the 80/20 principle, if the accumulated defects exceed 80%, corrective action needs to be taken

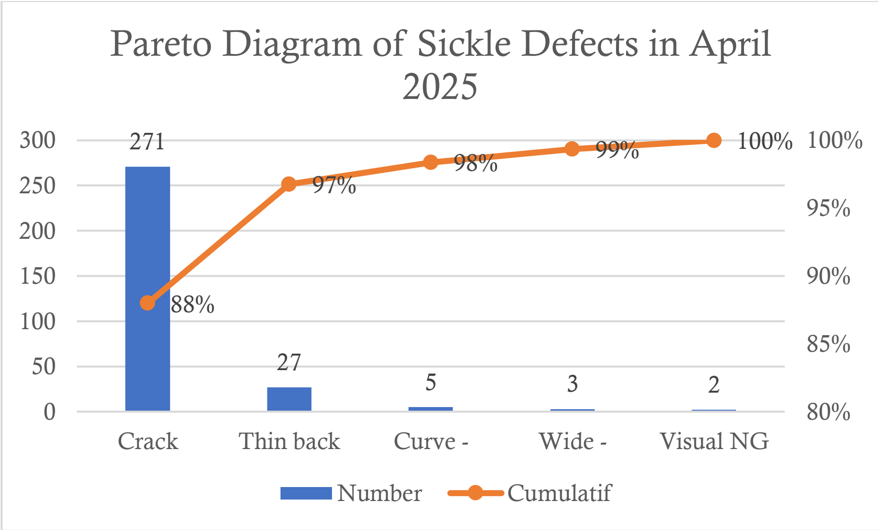

Figure 2. Pareto Diagram of Sickle Defects

Based on the pareto diagram, it is known that cracks are the most common type of defect in April, with a percentage of 88%. This result is in line with research conducted by Hakim & Oktadinata (2023), which shows that cracks in metal components after heat treatment are caused by internal stress and temperature inconsistencies. This confirms that process parameters and operator skills play an important role in preventing crack defects in sickle products.

4. Fishbone Diagram
Fishbone diagrams are used to identify the root causes of defects in sickle products. These diagrams are compiled based on the results of defect percentage analysis from Pareto diagrams, with the most common type of defect found being cracks.

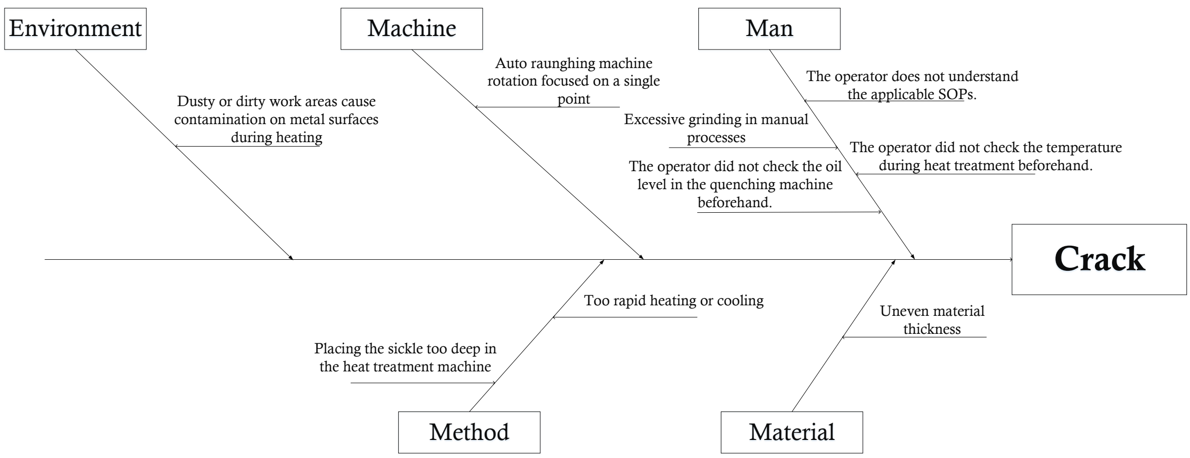

Figure 3. Fishbone Diagram of Sickle Defect

Based on the fishbone diagram analysis, cracks are caused by five main factors, man, machines, methods, materials, and the environment.

- Man: Operators lack understanding of SOPs due to a lack of regular training, SOP not being posted in the work area, weak supervision, and SOP language that is difficult to understand. In addition, operators are often in a hurry to meet targets, so they do not check the heat treatment temperature or oil level in the quenching machine, and perform excessive grinding.

- Machine: Grinding wheel rotation is uneven due to worn components, infrequent maintenance, and no recalibration after repairs.
- Method: The heating and cooling processes are too drastic because the machines do not have automatic temperature sensors, operators rely solely on estimates, and sickles are not positioned correctly due to the lack of guidelines.
- Material: Sickle thickness varies due to manual processes, so thin materials absorb heat more quickly during heat treatment.
- Environment: The dusty and dirty work area causes contamination on the metal surface, while the temperature and humidity are uncontrolled due to the absence of a cleaning schedule and work environment regulations.

After identifying the root cause using a Fishbone Diagram, The next step entails applying the Failure Mode and Effect Analysis (FMEA) method for analysis. This method is used to evaluate the severity of the impact of failure (Severity), the likelihood of failure occurring (Occurrence), and the effectiveness of detection of potential failures (Detection). The risk value is then calculated by multiplying these three components to obtain the Risk Priority Number (RPN).

***Failure Mode and Effect Analysis* (FMEA)**
The purpose of RPN (Risk Priority Number) in FMEA (Failure Mode and Effects Analysis) is to assess and prioritize failure risks numerically, so that teams can focus on the most important improvements to enhance the quality, safety, and reliability of products or processes.

Table 3. Table of RPN Calculations

Potential Failure Mode	Potential Effects of Failure	S	Potential Cause of Failure	O	Current Control	D	RPN
			Man:				
Crack (cracks on the sickle blade)	Cracks in the blade (sickle) can cause a decrease in cutting efficiency and pose a risk of breakage during use, potentially injuring the operator.	9	The operator does not understand the applicable SOPs	7	Notification regarding standards for production operators	5	315
		9	Excessive grinding in manual processes	6	Provide instructions and return products to operators for repair.	5	270
		9	The operator does not check the temperature during heat treatment beforehand	5	Use of thermoguns before the process begins	4	180
		9	The operator did not first check the oil level in the quenching machine	5	checking the oil level in the quenching machine	4	180
			Machine :				
		9	Auto raunghing machine rotation focused on a single point	5	Visual inspection of the machine before use	5	225
			Method :				

	9	The heating process is too fast or the cooling is too drastic	6	Performing hardness checks after the heat treatment process	4	216
	9	Placing the sickle too deep in the machine heattreatment	4	Using intuition when placing the sickle on the heat treatment machine	4	144
		Material :				
	9	The thickness of the material is not uniform	6	Sharpening the sharp area of a sickle	5	270
		Environment :				
	9	Dusty or dirty work areas	5	clean the sickle before the heat treatment process	6	270

Based on the table of factors causing crack defects, it is known that the highest RPN value comes from human factors, namely operators who do not understand the applicable SOP, with an RPN value of 315. Meanwhile, the lowest RPN value comes from method factors, namely placing the sickle too deep in the heat treatment machine, with an RPN value of 144.

According to the Risk Priority Number (RPN) calculation results listed in the table above, It can be seen that the causes of failure that lead to product defects are ranked from highest to lowest value. This ranking forms the basis for determining the priority of recommendations for improvements to each potential cause of failure. The following is a table of proposed improvements based on the Risk Priority Number (RPN) assessment.

These calculations form the basis for determining the priority of improvements for each potential cause of failure. These findings are in line with the research by Rahmawati & Suryana (2024), which states that consistent understanding and implementation of SOPs play an important role in reducing work errors and improving product quality.

Table 4. Table of Improvement Recommendations

Potential Failure Mode	Potential Cause of Failure	RPN	Recomendation
	The operator does not understand the applicable SOP	315	There needs to be notification regarding standards for all production operators, starting from standards in the process to the finished product, so that operators understand and implement SOPs correctly
	Excessive grinding in manual processes	270	Notice to manual grinder operators: what are the effects of excessive grinding in the manual grinding process
Crack	The thickness of the material is not uniform	270	Thicken the sharp edges by approximately 1-2 mm to avoid unwanted defects
	Dusty or dirty work areas	270	Perform routine cleaning around the heat treatment area and clean the sickle before the heat treatment process
	Auto raunghing machine rotation focused on a single point	225	It is necessary to adjust the auto raughing machine so that the grinding wheel does not focus on a single point, but rather rotates steadily and consistently

The heating process is too fast or the cooling is too drastic	216	Regulate the heating and cooling rates gradually according to process standards, using automatic temperature control
The operator does not check the temperature during heat treatment beforehand.	180	checking the temperature that must be achieved in the heat treatment process
The operator did not first check the oil level in the quenching machine.	180	checking the oil level in the quenching machine
Placing the sickle too deep in the heat treatment machine	144	Create a barrier on the heat treatment machine so that the placement is not too deep.

CONCLUSION

Based on research conducted at PT. ABC using the SQC (Statistical Quality Control) and FMEA (Failure Mode & Effect Analysis) approaches to reduce the number of dominant defects in sickle products, The analysis results show five main categories of defects, namely crack defects, thin backs, width defects, curve defects, and visual NG defects. Of these five types, crack defects are the most dominant. The analysis results show that the causes of crack defects are influenced by several factors, including human, machine, material, method, and environmental factors. Human factors are related to operators' lack of understanding of SOPs, excessive grinding, and failure to check the temperature and oil level before the process. Machine factors are caused by the auto roughing machine rotation focusing on a single point. Method factors include too rapid heating, too drastic cooling, and improper sickle placement during the heat treatment process. From the material side, the cause is inconsistent thickness, and humid working environment has the potential to cause contamination and micro-rust.

Proposed improvements to reduce defects in sickle production at PT. ABC focused on the main cause with the highest Risk Priority Number (RPN) value, namely the fact that operators did not understand the applicable SOPs. The proposed improvement was to provide notification of the standards to all production operators, as well as conducting regular and comprehensive SOP training and socialization for all operators. The main cause with the lowest Risk Priority Number (RPN) value is the sickle being placed too deep in the heat treatment machine. The proposed improvement is to create a barrier on the heat treatment machine so that the placement is not too deep.

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