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EQ Spacing Quality Control Using Statistical Quality Control and Fault Tree Analysis at PT Sinar Semesta

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***Abstract**. PT Sinar Semesta is a company engaged in the metal casting industry. In its production process, defects were still found during the period from March 2023 to February 2024. Out of a total production of 4,950 units, there were 1,004 defective units, consisting of 534 units with flow error defects and 470 units with porosity defects. To address this issue, quality control methods such as Statistical Quality Control (SQC) and Fault Tree Analysis (FTA) are necessary to minimize product defects, improve quality, and maintain high standards. Based on the Pareto diagram, the most dominant defect percentages are flow error defects at 53.19% and porosity defects at 46.81%. The control chart shows points beyond the upper control limit (UCL) occurring in April with 148 units, May with 145 units, and October with 149 units, and below the lower control limit (LCL) occurring in August with 35 units, January with 36 units, and February with 32 units. Based on the fault tree analysis, five main factors causing defects were identified: human, machine, raw material, method, and environment. Proposed improvements include operator training, routine machine maintenance, accurate raw material measurement, use of high-quality raw materials, pre-pouring temperature checks, increased supervision, and environmental improvements.*

***Keywords**: Eq Spacing, Defects, FTA, SQC, Satisfaction*

1. INTRODUCTION

The manufacturing industry has experienced rapid development in recent years due to advances in science and technology. As the number of manufacturing and service companies increases, competition among these companies becomes more intense. In this industry, product quality is a key factor that consumers consider when making purchasing decisions. Quality is defined as the ability of a product to meet user expectations and comply with established standards. Therefore, it is crucial for companies to maintain high-quality standards to remain competitive and ensure customer satisfaction.

PT Sinar Semesta, a company focused on metal casting, always prioritizes product quality to maintain customer satisfaction. Although the company has successfully expanded its market and maintained its position, there are still challenges in the production process, particularly those related to product defects that can negatively impact quality and profitability. This highlights the need for more effective quality control methods.

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To address the issue of product defects, implementing quality control methods such as Statistical Quality Control (SQC) and Fault Tree Analysis (FTA) is essential. SQC is a statistical process for monitoring and controlling quality, helping to measure, observe, and manage product or service quality. SQC involves analyzing sample characteristics to draw conclusions about production quality (Purilistianto et al., 2022). FTA is an analytical technique that uses graphical fault models to identify and evaluate potential failures in the production process. FTA includes various combinations of errors that can lead to undesirable events, making it highly relevant for identifying product defects (Zainal Muttaqin & Isnaini, 2023).

By implementing SQC and FTA, this study aims to reduce the product failure rate at PT Sinar Semesta and ensure customer satisfaction through improved product quality. This research will identify the causes of product defects and evaluate the effectiveness of both methods in controlling production quality. Additionally, this study will provide recommendations for improvements to enhance product quality and the production process at PT Sinar Semesta.

2. METHODS

This study aims to identify the root causes of product defects and assess the effectiveness of quality control methods in the production process at PT Sinar Semesta. The research employs the Statistical Quality Control (SQC) method with the Seven Tools approach and Fault Tree Analysis (FTA). The research stages include:

1. Research Design

This study uses a quantitative approach with a descriptive-analytical method. The data collected includes primary data from the production process and secondary data from PT Sinar Semesta's product quality records.

2. Implementation of Statistical Quality Control with Seven Tools

The Seven Tools are used to analyze product defect data and identify the main causes of quality issues. The implementation stages of the Seven Tools are as follows:

a. Stratification

Stratification is the grouping of data based on similar characteristics. Its benefits include facilitating the identification of main quality causes, assisting in the creation of Scatter Diagrams, and gaining a deeper understanding of issues (Pranata Primisa Purba et al., 2022).

b. Check Sheet

A Check Sheet is used to simplify data collection for communicative purposes and to facilitate the transformation of data into useful information (Andespa, 2020).

c. Histogram

A Histogram is a graphical tool used to assess variations in a process by organizing data into a frequency distribution. The shape of the histogram can provide insights into data distribution and production process trends (Setiawan, 2021).

d. Pareto Diagram

The Pareto Diagram is a graphical representation that uses a combination of bars and lines to illustrate the comparison of various types of data against the whole. This diagram helps identify key issues and establish priorities for resolution (Hangesthi et al., 2021).

e. Scatter Diagram

The Scatter Diagram is used to show potential relationships between two variables and to measure the strength of this relationship, usually expressed as a correlation coefficient (Sutiyono et al., 2023).

f. Control Chart

The Control Chart is a graphical tool used to monitor activities or processes in quality control, aiming to identify problems and improve quality (Rucitra & Amna, 2021).

g. Cause and Effect Diagram (Fishbone Diagram)

The Cause and Effect Diagram is used to identify and highlight factors that influence quality characteristics and their impact on the production process (Sondakh & Wahyuningtyas, 2021).

3. Implementation of Fault Tree Analysis (FTA)

Fault Tree Analysis (FTA) is used to investigate the root causes of failures in the production process (Masykur & Oktora, 2021). This approach involves identifying key events, constructing a fault tree, analyzing fault combinations, and recommending improvements to reduce future failure risks (Yolanda et al., 2023). This process aims to enhance the reliability and overall quality of the production process .

3. RESULTS

Production data and defect rate in the manufacturing of Eq Spacing at PT Sinar Semesta from March 2023 to February 2024 are as follows:

Table 1. Production and Defect Rate

Period	Production	Defect		Total Defect
		Flow Error	Porosity	
March	400	40	4	44
April	400	57	91	148
May	400	78	67	145
June	400	6	97	103
July	400	55	6	61
August	400	11	24	35
September	400	71	4	75
October	400	98	51	149
November	400	39	35	74
December	450	41	61	102
January	450	26	10	36
February	450	12	20	32
Total	4950	534	470	1004

Seven Tools Method

In processing data related to product defects in the production of Eq Spacing at PT Sinar Semesta, several steps are taken using the Seven Tools method. These steps include identifying product defects using tools consisting of these seven methods:

1. Stratification

Stratification involves grouping defect data into categories with similar characteristics. Below are various types of production defects:

Table 2. Types of Defects in Eq Spacing

Type of Defect	Description
Flow Error	Flow error occurs when the mold cavity is not completely filled with molten metal, often caused by a blockage due to the molten metal solidifying before reaching the entire mold cavity.
Porosity	Porosity is a defect that causes damage to the Eq Spacing product, making it incomplete. This defect occurs on the outer part of the product, visible directly, and is caused by the erosion of the mold sand.

2. Check Sheet

PT Sinar Semesta uses a check sheet observation form to inspect the production results and defective products (Astini & Imaroh, 2021). The most common defects recorded in Eq Spacing products are Flow Error and Porosity.

Table 3. Check Sheet for Defective Products

Period	Production	Defect		Total Defect
		Flow Error	Porosity	
March	400	40	4	44
April	400	57	91	148
May	400	78	67	145
June	400	6	97	103
July	400	55	6	61
August	400	11	24	35
September	400	71	4	75
October	400	98	51	149
November	400	39	35	74
December	450	41	61	102
January	450	26	10	36
February	450	12	20	32
Total	4950	534	470	1004

Based on the Check Sheet, the total production at PT Sinar Semesta from March 2023 to February 2024 was 4950 units. Data analysis shows that October had the highest number of defective products, with 149 defective Eq Spacing units, consisting of 98 flow error units and 51 porosity units.

3. Control Chart

A control chart is a graphical tool used to monitor the stability of a work process, helping to determine whether a process is in control or not (Agustiandi et al., 2021). In a control chart, calculations are made for the defect proportion, center line, upper control limit (UCL), and lower control limit (LCL) to determine the control limits for defects in Eq Spacing products.

Table 4. Control Chart for Eq Spacing Product

Period	Production	Total Defect	Defect Proportion	CL	UCL	LCL
March	400	44	0.11	0.203	0.303	0.102
April	400	148	0.370	0.203	0.303	0.102
May	400	145	0.363	0.203	0.303	0.102
June	400	103	0.258	0.203	0.303	0.102
July	400	61	0.153	0.203	0.303	0.102
August	400	35	0.088	0.203	0.303	0.102
September	400	75	0.188	0.203	0.303	0.102
October	400	149	0.373	0.203	0.303	0.102
November	400	74	0.185	0.203	0.303	0.102
December	450	102	0.227	0.203	0.303	0.102
January	450	36	0.080	0.203	0.303	0.102
February	450	32	0.071	0.203	0.303	0.102

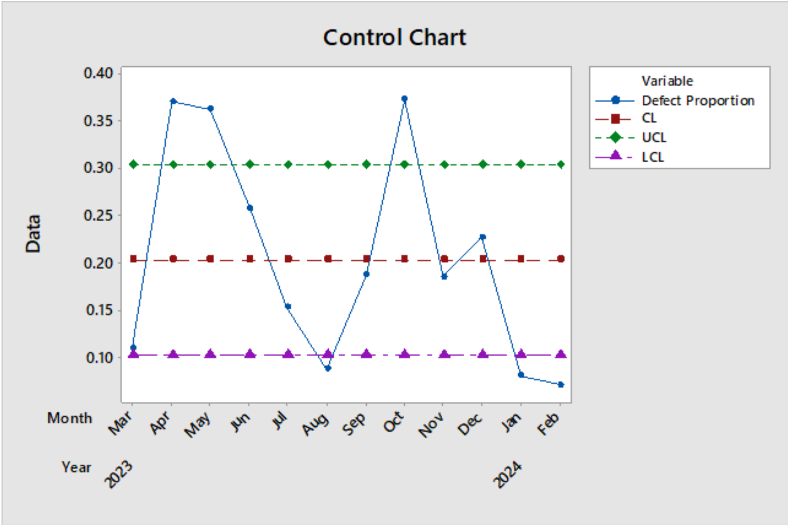


Figure 1. Control Chart for Quality Analysis of Eq Spacing Product

The analysis of the control chart shows points beyond the upper control limit (UCL) and lower control limit (LCL). Defects that exceed the upper limit occurred in April with 148 units at a proportion of 0.370, May with 145 units at 0.363, and October with 149 units at 0.373. On the other hand, defects below the lower limit occurred in August with 35 units at 0.088, January with 36 units at 0.080, and February with 32 units at 0.071. This situation indicates data instability and suggests that the company needs to make improvements in the production process.

4. Histogram

A histogram is used to determine the most frequent types of defects. Below is a histogram based on product defects from March 2023 to February 2024.

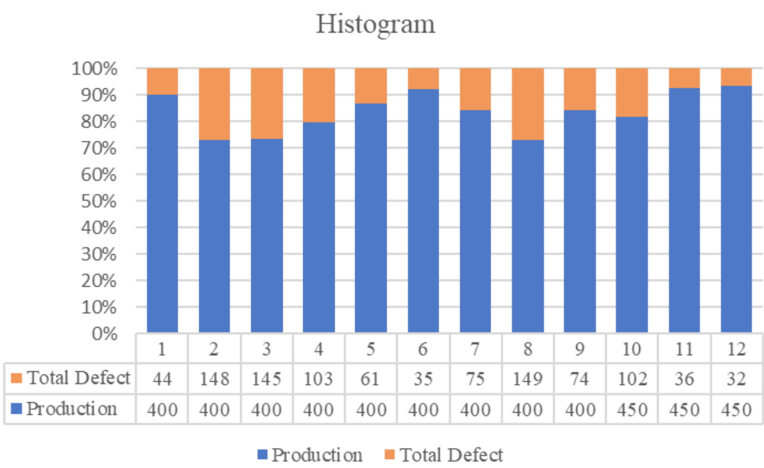


Figure 2. Histogram of Defects in Eq Spacing Products

The graph shows that the types of defects occurring from March 2023 to February 2024 follow a clear pattern. The month with the highest number of defective products was October, with 98 cases of flow error defects and 51 cases of porosity defects. Meanwhile, February had the fewest defective products, with only 12 cases of flow error defects and 20 cases of porosity defects.

5. Pareto Diagram

The Pareto diagram is used to identify the main factors causing a specific problem or situation (Sutjipto et al., 2022). In this context, the Pareto diagram analysis is used to evaluate the defect data of Eq Spacing products from March 2023 to February 2024.

Table 5. Pareto Diagram of Defect Types

Type of Defect	Presentage	Cumulative Percentage
Flow Error	53,19%	53,19%
Porosity	46,81%	100%

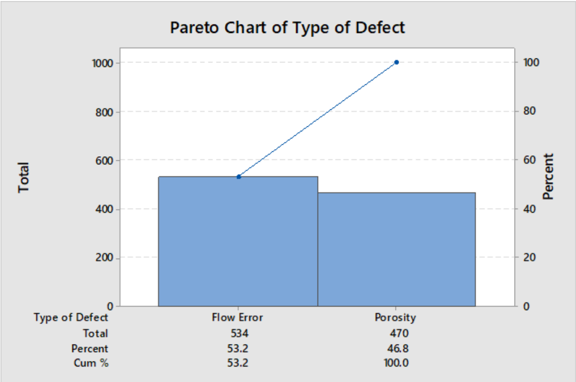
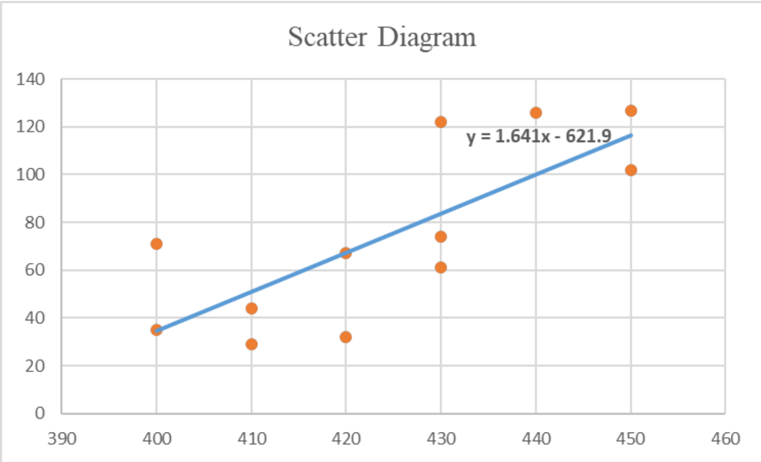


Figure 3. Pareto Diagram of Defect Types

The diagram shows that 524 units of Eq Spacing products had misalignment defects, with a defect percentage of 53.19%. Meanwhile, 470 units of Eq Spacing products had porosity defects, with a percentage of 46.81%. This shows that the most frequent defect is misalignment, with 534 units and a percentage of 53.19%. The cumulative percentage for the types of defects is 53.19% and 100%.

6. Scatter Diagram

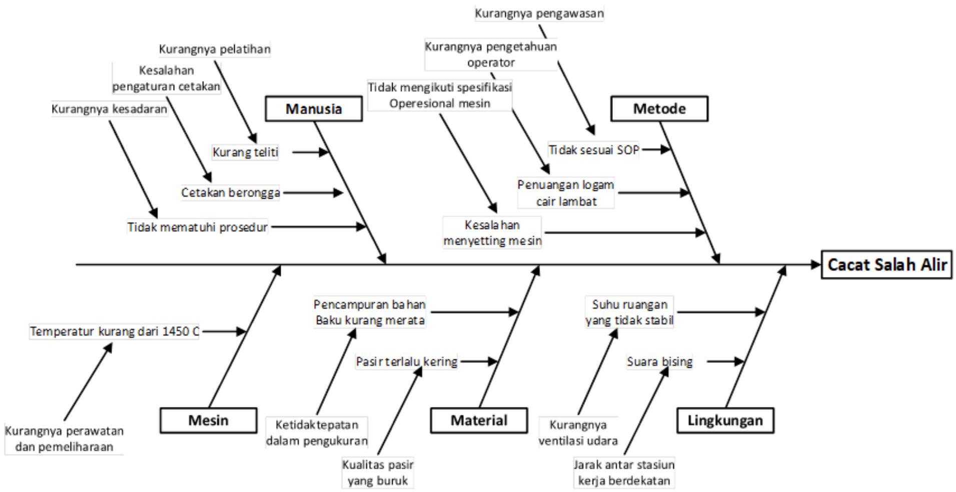
A scatter diagram is a visualization that shows the potential relationship between two variables and illustrates the degree of association between them through the correlation coefficient.



When applied to variable X (production quantity) and variable Y (number of defective products), the scatter diagram indicates that there is no clear linear pattern between these two variables. Instead, the data points are scattered randomly or show a non-linear pattern that cannot be explained by a linear relationship. This suggests that there is no significant correlation between the number of defective products and the production quantity. In other words, there is no clear trend that changes in production quantity will lead to specific changes in the number of defective products.

7. Cause and Effect Diagram (fishbone)

The cause and effect diagram is used to analyze various factors that contribute to product defects (Ignatius & Sutanto, 2021). The types of defects analyzed are flow error and porosity defects.



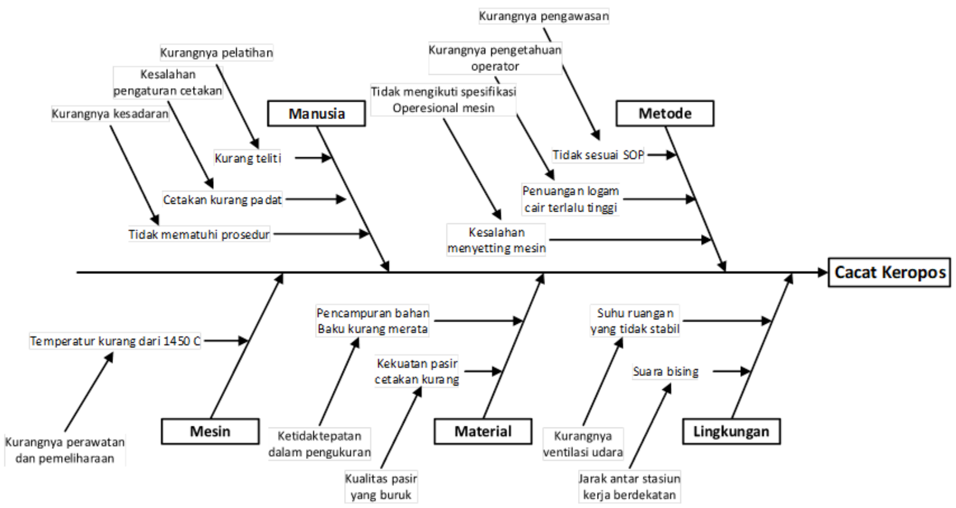
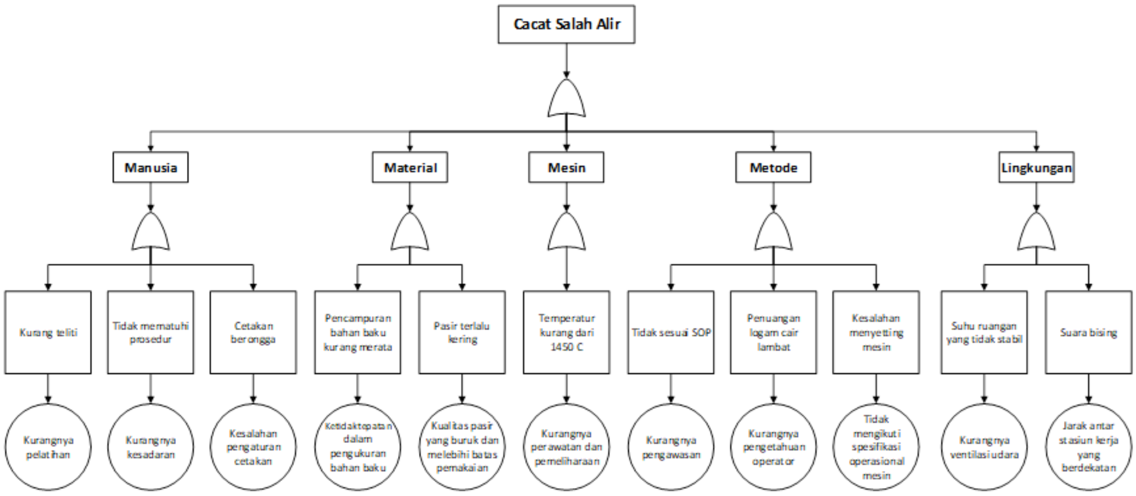


Figure 4. Cause and Effect Diagram

This diagram indicates that there are five main factors causing product defects: human factors, machinery, raw materials, methods, and the environment. Human factors include fatigue, lack of attention to metal temperature, low accuracy, and procedural violations. Machinery factors involve suboptimal performance and lack of maintenance. Raw materials can be problematic due to insufficient molten metal or uneven mixing. Additionally, poor production methods, such as excessively high metal pouring speed, can also lead to defects. An unsupportive work environment, such as poor air circulation and noise, also plays a role in the occurrence of product defects.

Fault Tree Analysis Method

Fault Tree Analysis (FTA) is a method used to identify the root causes of failures that can lead to system malfunctions in products or services. This method employs a top-down approach to analyze various risks contributing to failure. In the case study of Eq Spacing products at PT Sinar Semesta, FTA was utilized to understand the causes of defects such as flow error and porosity.



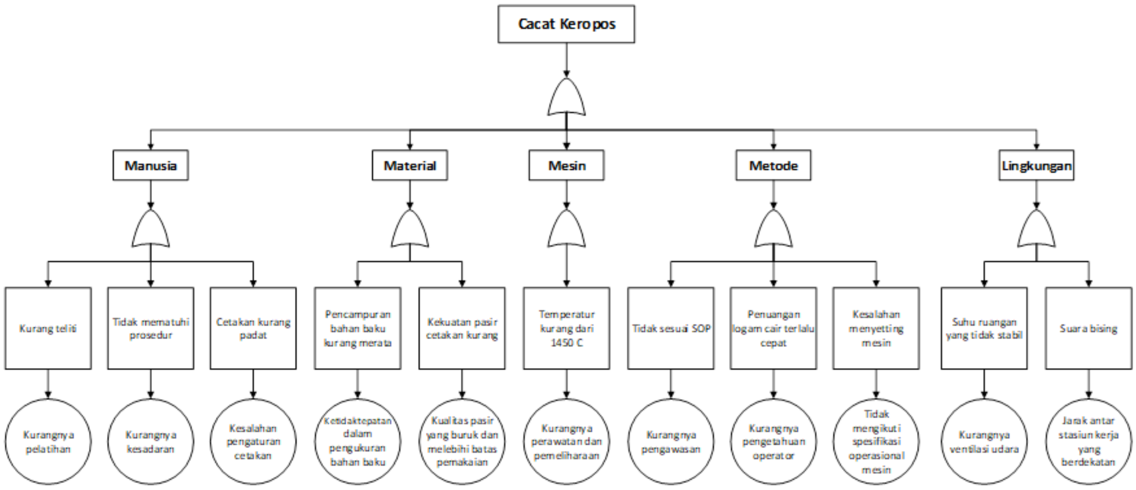


Figure 5. Fault Tree Analysis

The analysis revealed five main factors contributing to product defects: human, machine, raw materials, method, and environment. Human factors include fatigue, lack of attention to metal temperature, inaccuracy, and procedural violations. Machine-related factors involve suboptimal performance and lack of maintenance. Raw material issues include insufficient liquid metal, uneven mixing, and low-quality sand. Method-related factors consist of excessive metal pouring speed and incorrect machine settings, while environmental factors involve poor air ventilation and workplace noise.

As part of the improvement process, recommendations were made based on the FTA analysis to enhance product quality. Proposed solutions include operator training, regular machine maintenance, improved accuracy in raw material measurement and the use of high-quality raw materials, temperature inspection before pouring, increased supervision of SOP compliance, as well as better air ventilation and the use of temperature control devices and ear protection.

4. CONCLUSION

During the production period from March 2023 to February 2024, PT Sinar Semesta produced 4,950 units of Eq Spacing products. Analysis identified two primary defects: flow error defects accounting for 53.19% and porosity defects at 46.81%. The control chart revealed several points beyond normal limits, indicating instability in the production process. Defects exceeding the upper limit were observed in April, May, and October, while defects below the lower limit occurred in August, January, and February. Based on the fishbone diagram and Fault Tree Analysis, proposed solutions include operator training, machine maintenance, raw material monitoring, production method improvements, and workplace environment enhancements.

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