

Analysis of Product Quality Control of Visors Using the Seven Quality Tools Method at PT. Solo Plastik Indonesia

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Abstract

Quality control is a critical aspect of the production process to minimize non-conforming products (NG). PT. Solo Plastik Indonesia still encounters quality issues in visor products, particularly silver and jetting NG. This internship research aims to analyze visor product quality control using the Seven Quality Tools method with a descriptive quantitative approach. Data were collected through direct observation, production and NG records, and interviews with visor production operators. The analytical tools applied include checksheets, histograms, stratification, Pareto diagrams, P control charts, scatter diagrams, and cause-and effect (fishbone) diagrams strengthened by observational indicators and quantitative scoring. Pareto analysis results show that in shift 1, silver and jetting NG are the dominant NG types with a cumulative percentage of 84%, while in shift 2 the cumulative percentage reaches 81%. P control chart analysis indicates that each shift has three out-of-control points, indicating that the production process is not yet fully under statistical control. Fishbone analysis shows that the material factor has the highest score contribution at 31,25%, followed by method at 30% and machine at 22,5%, while environment and man factors contribute 8,75% and 7,5%, respectively, and the measurement factor contributes 0%. Overall, the application of Seven Quality Tools is effective in identifying dominant NG types and their main causes as a basis for quality improvement at PT. Solo Plastik Indonesia.

Keywords: quality control, Seven Quality Tools, NG products, visor.

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Introduction

1.1 Competition in the global manufacturing industry, particularly in the automotive sector, requires companies to produce components with high precision, extremely low defect rates, and consistent quality maintained over time. Even a minor failure in a single component can trigger large-scale recalls that result in significant financial losses and damage to brand reputation (Maione et al., 2023). Therefore, quality control is no longer merely a competitive advantage but has become an operational necessity that must be fulfilled.

The obligation to maintain product quality is further reinforced by regulations such as Indonesian Law No. 20 of 2014 on Standardization and Conformity Assessment, as well as the implementation of international quality management standards such as ISO 9001 and IATF 16949 in the automotive industry, which require documented, measurable, and continuous quality control and improvement processes. These standards aim not only to protect consumers but also to enhance product competitiveness within the global supply chain.

In the context of the automotive industry, visors are among the critical components that demand high visual and functional quality, including optical clarity, dimensional conformity, and freedom from surface defects such as scratches, spots, flow marks, and other imperfections. Such defects can reduce product value and trigger customer complaints; therefore, data-based quality analysis of produced visor components becomes an essential step to assess actual quality conditions and serve as a foundation for subsequent quality improvement initiatives.

According to the American Society for Quality (ASQ, 2025), the seven basic quality control tools, commonly referred to as the Seven Quality Tools, include the check sheet, stratification, control chart, Pareto diagram, cause-and-effect (fishbone) diagram, scatter diagram, and histogram. These tools are designed to assist in identifying quality problems, analyzing their root causes, and systematically monitoring improvement outcomes. ASQ (2025) also emphasizes that the Seven Quality Tools are easy to use by practitioners on the production floor and are capable of addressing the majority of quality-related problems.

Daily quality problems, making it an approach widely recommended across various types of industries. Numerous previous studies have demonstrated the effectiveness of the Seven Quality

Tools method in identifying and reducing product defects across different industrial sectors. Ananda et al. (2025) showed that the application of the Seven Quality Tools to tempeh products at Rumah Tempe Indonesia was able to determine the most common types of defects, identify their causes, and serve as a basis for formulating targeted quality improvement recommendations. Prabaswari and Susilo (2020) found that the use of the Seven Tools approach in Chippendale furniture products was effective in reducing defect rates by focusing improvement efforts on the main defect types and their root causes, as identified through Pareto charts and fishbone diagrams.

These research findings reinforce that quality analysis based on the Seven Quality Tools applied to finished product defect data is a proven and relevant approach for achieving continuous product quality improvement across various industrial contexts. PT Solo Plastik Indonesia (PT SPI) is a manufacturing company that produces automotive components made from plastic and rubber, one of which is visor products. The company conducts quality inspections on finished products to ensure compliance with customer standards and specifications and classifies products as either acceptable (OK) or nonconforming (NG/No Good) based on visual and dimensional criteria.

In practice, the company continues to face challenges related to the occurrence of NG products, particularly due to defects at the edge areas that require additional crushing and rework activities, which in turn increase processing time and costs. Quality inspection data that record the number and types of visor defects or NG products over a given period contain valuable information regarding defect patterns and therefore have significant potential for further analysis. However, based on the literature review conducted, no documented studies have been found that specifically apply the Seven Quality Tools method to analyze quality control of visor products at PT SPI.

This condition creates an information gap that needs to be addressed, positioning this study as an initial effort to resolve quality-related issues within the company. Previous studies have widely applied the Seven Quality Tools across various manufacturing industries, such as food products, furniture, and plastic packaging; however, the specific context of visor products at PT SPI has not yet been examined in depth. Therefore, this internship (Kerja Praktek) is focused on filling this gap by applying the Seven Quality Tools to analyze NG data of visor products, identify dominant NG types, trace contributing factors, and propose data-driven improvement recommendations to the company.

Based on the background elaborated above, the research questions are formulated as follows:

1. What is the quality condition of visor products at PT Solo Plastik Indonesia based on defect data observed during the study period?
2. How can the Seven Quality Tools be applied to analyze quality control of visor products at PT Solo Plastik Indonesia?
3. What are the most common NG types and their main causes, and what improvement recommendations can be proposed based on the results of the Seven Quality Tools analysis?

Research Method

PT Solo Plastik Indonesia is a manufacturing company operating in the automotive component production sector, specializing in plastic and rubber-based products. The company is located in the SIKIM industrial area, Jl. Majalengka Ring Road No. 3, Cikasarung, Majalengka District, Majalengka Regency, West Java, Indonesia. This location was selected based on the availability of visor component production processes and the existence of a documented quality inspection system, which supports the application of the Seven Quality Tools method to product defect data.

The study was conducted over an effective period of six weeks, from September 22, 2025, to October 31, 2025. During this period, activities included company familiarization, process observation, quality data collection, data processing, and report preparation.

The data analysis method employed a descriptive quantitative approach through the application of the Seven Quality Tools in accordance with the American Society for Quality (ASQ) guidelines, namely the check sheet, stratification, histogram, Pareto diagram, p-chart, scatter diagram, and fishbone diagram. The stages of analysis were designed to ensure a clear and systematic flow from data collection to conclusion drawing, as outlined below:

Check Sheet

The first step involved designing and using a check sheet to collect and summarize quality data of visor products. The recorded data included production frequency, NG frequency, and types of NG observed during each work shift, thereby enabling the identification of NG frequencies by defect type and time period.

Histogram

Histograms were used to illustrate the frequency distribution of quality data, such as the number of NG occurrences or the proportion of NG per observation period. The data were grouped into appropriate class intervals, frequencies were calculated, and the results were presented in bar charts to visualize data dispersion patterns and identify indications of abnormal variation.

Data Stratification

The collected data were subsequently stratified based on relevant categories, such as time periods (daily or per shift) or other available grouping variables. Stratification was conducted by separating the data into distinct groups and then comparing quality indicators (e.g., number or proportion of NG) across groups to identify which groups exhibited higher NG levels and therefore required further attention.

Pareto Diagram (Pareto Chart)

A Pareto chart was constructed to determine the most dominant NG types based on NG frequency data obtained from the check sheet. The procedure involved calculating the frequency of each NG type, ranking them from highest to lowest, computing percentages and cumulative percentages, and then displaying the results using bar charts and a cumulative line. NG types located in the initial segment of the cumulative curve (representing the largest contribution) were selected as the primary focus for root cause analysis and improvement efforts.

P Control Chart (P-Chart)

The P-chart method was specifically selected because the analyzed data consisted of attribute data, namely the proportion of nonconforming (NG) units. This chart was used to monitor variations in the proportion of NG products per daily sample subgroup.

The center line (\bar{p}) and control limits (UCL and LCL) were calculated using the three-sigma (3σ) formula. NG proportion points were plotted to evaluate whether the process operated under statistical control. The presence of points outside the control limits or non-random patterns (such as consistent runs or trends) indicated the occurrence of special cause variation, which required immediate corrective action.

Scatter Diagram

A scatter diagram was employed to analyze the relationship between operating hours per shift (independent variable) and the proportion of NG products (dependent variable) within the same period. Each pair of operating hours and NG frequency data was plotted as a single point on the graph, with operating hours on the X-axis and NG frequency on the Y-axis. The distribution pattern of the points was then examined to assess whether a positive correlation, negative correlation, or no clear relationship existed between operating duration and NG product levels.

Fishbone Diagram

The fishbone diagram was used to identify and organize potential causes of the dominant NG types previously determined through the Pareto chart. The diagram structure adopted the 5M+1E categories (Man, Machine, Method, Material, Measurement, and Environment), which were populated with causal factors and corresponding indicators derived from observations, interviews, and discussions with company personnel. These indicators were subsequently evaluated using a Likert scale to determine the relative dominance of each factor. This approach facilitated the identification of the most probable root causes, which then served as the basis for formulating proposed improvements in visor product quality control.

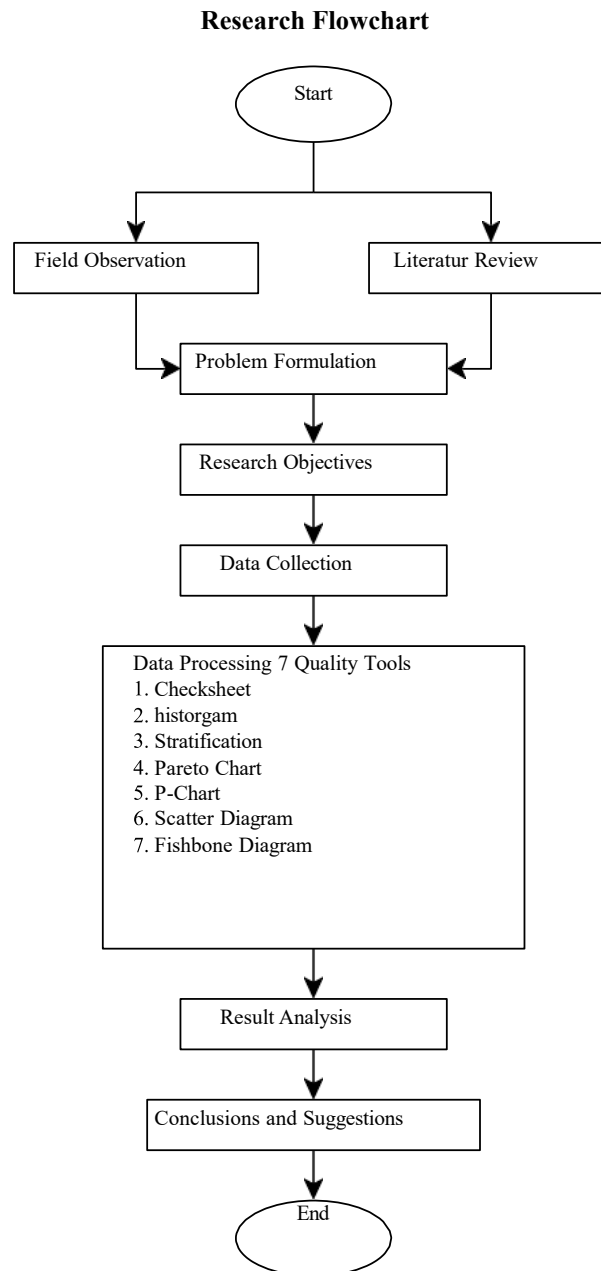


Figure 1. Flowchart

This flowchart illustrates the research process, which begins with field observations and a literature review to obtain an overview of actual conditions and establish a relevant theoretical foundation. These activities subsequently serve as the basis for problem formulation. Once the problems are clearly defined, the research objectives are determined to provide direction and focus for the intended analysis.

The next stage involves data collection in accordance with the research objectives, followed by data processing using the Seven Quality Tools. These include the check sheet for data recording, the histogram for identifying distribution patterns, stratification for data grouping, the Pareto diagram for problem prioritization, the P control chart for evaluating process stability, the scatter diagram for analyzing relationships between variables, and the fishbone diagram for identifying the root causes of problems.

The results of the data processing are then discussed in the analysis stage, after which they are summarized in the conclusions and recommendations as the final output of the study.

Results and Discussion

Quality control of visor products at PT SPI is based on a standard document known as the Qpoint Visor, which visually defines the acceptance criteria (GRADE A) and rejection criteria for each area of the product. This document serves as the primary reference for operators and the quality control (QC) team when conducting inspections. Permissible General NG (Minimum, Within Sample Limits): These include Silver, Black Dot, Flow Mark, Cloudy, Burn Mark, Scratch, Blurriness, and Bending.

NG Strictly Prohibited in Critical Areas (Part Check & P/L Part): These include Short Mold, Flashing, Crack, Broken parts, Burn Mark, and uncovered Holes. The diversity of NG types observed in visor products indicates the presence of variations in process parameters or external influencing factors. The identification and classification of these NG types are crucial as an initial step in the Seven Quality Tools analysis to determine priority areas for improvement. In general, these NG types can be further categorized and analyzed using the 5M + 1E framework (Man, Machine, Method, Material, Measurement, and Environment) to identify their root causes. The characteristics of each NG type are described as follows:

- a. Start-Up Production (AMP – Awal Masuk Produksi):
 A general NG referring to defective products occurring at the beginning of a production cycle after machine setup, mold change, or maintenance activities. This NG is typically caused by unstable temperature, pressure, or material conditions that have not yet reached optimal operating parameters.
- b. Short Shot / Short Mold:
 An incompletely formed product that fails to fill the mold cavity fully due to insufficient injection volume, low injection pressure, material temperature that is too low, or restricted flow velocity.
- c. Silver (Silver Streak / Splay Mark):
 Appears as thin, silver-like streaks spreading across the product surface. This defect is caused by high moisture content in the material (insufficiently dried resin), trapped air, or thermal degradation of the material.
- d. Over Cut:
 Product damage resulting from excessive cutting of the runner or gate, which distorts the product edge geometry and exceeds allowable tolerance limits.
- e. Sink Mark:
 Localized depressions or shrinkage on the product surface, particularly in thicker sections. This defect occurs due to insufficient holding or packing pressure to compensate for material shrinkage during cooling, or an excessively short cooling time.
- f. Black Dot:
 Small black spots or stains appearing on the product surface. These are caused by material contamination, burned foreign particles inside the machine barrel, or material degradation due to excessively high processing temperatures.
- g. Weld Line:
 Thin lines formed where two material flow fronts meet but fail to fuse completely. This defect is commonly caused by low material or mold temperature, or excessively slow injection speed.
- h. Scratch:
 Linear surface damage on the product. Scratches are often caused by friction during the ejection process, improper handling, or contact with rough surfaces in the work area.
- i. Flow Mark:
 Flow patterns or wave-like marks visible on the product surface. These occur when material flows at inconsistent speeds or when material temperature is too low, resulting in uneven cooling.
- j. Bubble (Void):
 Air bubbles or gas pockets trapped within the product material. This defect is caused by material moisture, poor mold venting, or excessively high filling speed.
- k. Crack:
 Cracks or fractures in the product. These may result from residual stress due to rapid cooling,

excessive ejection force, or product designs with sharp corners.

l. Jetting:

A defect resembling a snake-like pattern near the gate area. It occurs when material enters the mold cavity at very high speed and cools prematurely before spreading and fusing smoothly.

m. Cloudy (Hazy Appearance):

Opaque or cloudy areas on transparent products such as visors. This defect is typically associated with low mold temperature, rapid cooling rates, or raw material with inadequate transparency quality.

n. Hair Mark:

Extremely fine, hair-like lines on the product surface. These are often caused by fiber contamination or fine impurities present in the material or on the mold surface.

o. Dirty:

Surface contamination from dust particles, oil, or other foreign substances. This defect occurs due to poor production environment cleanliness, lubricant leakage, or unhygienic product handling.

p. Dented:

Small dents or indentations on the product surface, usually caused by physical impact after the injection process or during handling and packaging activities.

Each product unit that fails to meet the specified visual or dimensional criteria is categorized as NG (No Good) and separated from OK products. The inspection results are then recorded by QC personnel in a daily check sheet containing information on total production quantity, NG quantity, NG types, and the observation period per work shift.

The data collected from these check sheets are subsequently compiled into tables of production and NG quantities per shift, as well as frequency tables of NG types. These compiled datasets then serve as the primary input data for the Seven Quality Tools analysis.

Seven Quality Tools Method

The application of the Seven Quality Tools in this study aims to analyze visor product quality data in a structured manner, starting from data collection and grouping, understanding variation patterns, determining problem priorities, analyzing relationships between variables, and ultimately identifying the root causes of NG occurrences. The tools employed include the check sheet, stratification, histogram, Pareto chart, P control chart, scatter diagram, and cause-and-effect (fishbone) diagram.

Visor Production Data Collection (Check Sheet)

The quality data used in this analysis consist of inspection results of visor products during the October 2025 period at PT Solo Plastik Indonesia. The data include daily production quantities, the number of units classified as NG, work cycle times for each shift, and a summary of NG types identified by the Quality Control (QC) department.

This information was recorded in daily check sheets and subsequently compiled into tables of daily production and NG data (per shift), which served as the basis for analysis using the Seven Quality Tools.

Table 1. Checksheet daily production of visor PT. SPI

Date	Shift	Operational Hour (jam)	Production (pcs)	Total OK (pcs)	Kind of NG						Total NG (pcs)
					AMP (pcs)	SHOT (pcs)	SILVER (pcs)	BLACK DOT (pcs)	JETTING (pcs)	CLOUDY (pcs)	
1	2	11	827	810	0	0	8	6	0	3	17
2	1	11	1.002	985	0	1	11	0	5	0	17
2	2	11	1.005	985	0	0	6	6	8	0	20
3	1	11	1.003	985	0	0	15	0	3	0	18
3	2	11	883	835	0	1	10	10	27	0	48

4	1	11	912	900	0	0	10	2	0	0	12
4	2	11	860	830	4	2	8	6	10	0	30
5	2	11	923	900	0	0	15	0	8	0	23
6	1	11	870	830	0	0	8	10	22	0	40
6	2	11	912	900	0	2	9	1	0	0	12
7	1	4	345	340	0	0	1	0	4	0	5
7	2	7	568	560	0	0	8	0	0	0	8
8	1	4	345	340	0	0	0	3	2	0	5
8	2	10	824	815	0	7	0	2	0	0	9
9	1	11	911	900	0	0	5	2	4	0	11
9	2	11	909	900	0	0	9	0	0	0	9
10	1	8	773	765	0	0	4	1	3	0	8
12	2	10	814	808	4	2	0	0	0	0	6
13	1	8	690	680	0	0	9	1	0	0	10
13	2	11	858	830	2	2	8	3	13	0	28
14	1	2	177	170	0	0	7	0	0	0	7
16	1	8	696	680	6	0	10	0	0	0	16
16	2	11	843	780	4	2	8	6	43	0	63
17	1	11	914	900	0	0	12	2	0	0	14
17	2	8	660	650	0	0	3	2	5	0	10
18	1	11	915	900	0	0	14	1	0	0	15
20	1	10	805	800	4	0	1	0	0	0	5
20	2	8	694	680	0	0	14	0	0	0	14
21	1	11	752	710	2	2	8	6	24	0	42
21	2	11	915	900	0	0	15	0	0	0	15
22	1	11	920	900	0	0	6	5	9	0	20
22	2	11	915	900	0	0	15	0	0	0	15
23	1	11	866	850	0	0	6	5	5	0	16
23	2	8	694	680	0	0	14	0	0	0	14
24	2	7	614	600	0	0	14	0	0	0	14
25	1	4	320	300	0	0	20	0	0	0	20
25	2	8	695	680	0	0	15	0	0	0	15
26	1	8	666	645	2	2	8	2	7	0	21
27	1	11	917	900	0	0	17	0	0	0	17
27	2	11	874	860	3	0	11	0	0	0	14

28	1	11	917	900	0	0	17	0	0	0	17
28	2	11	580	540	0	0	11	0	29	0	40
29	1	11	996	980	0	0	16	0	0	0	16
29	2	10	828	815	0	0	13	0	0	0	13
30	1	8	691	680	0	0	11	0	0	0	11
30	2	8	665	645	2	2	7	4	5	0	20
31	1	11	1.000	985	0	0	15	0	0	0	15
31	2	11	727	700	3	0	13	0	11	0	27
Total			37.490	36.628	36	25	465	86	247	3	862

Therefore, the check sheet in this study serves as the foundation of the entire Seven Quality Tools analysis, as it provides structured raw data for the construction of histograms, Pareto charts, P control charts, and scatter diagrams.

Histogram

The histogram is used as an initial step to analyze the frequency distribution of daily NG occurrences in visor production at PT Solo Plastik Indonesia during the observation period. The data used are obtained from the check sheets, which record the number of NG products on each production date.

Table 2. Frequency of NG visor harian

Tgl	Jumlah NG	Tgl	Jumlah NG
1	17	17	24
2	37	18	15
3	66	20	19
4	42	21	57
5	23	22	35
6	52	23	30
7	13	24	14
8	14	25	35
9	20	26	21
10	8	27	31
12	6	28	57
13	38	29	29
14	7	30	31
16	79	31	42

Based on the table above, the daily NG data were first grouped into several class intervals. The grouping was performed using Sturges' formula to determine the number of classes (k), as follows: $k = 1 + 3,3 \log(n)$

The number of observations (n) = 28 days; therefore:

$$k = 1 + 3,3 \log(28) = 1 + 3,3(1,447) = 5,77 \approx 6 \text{ class}$$

The data range was calculated by subtracting the minimum value (6) from the maximum value (79), resulting in a range (R) of 73. The class width was then determined as follows: $\text{Lebar kelas} = \frac{R}{k} = \frac{73}{6} = 12,16 \approx 12$

Based on these calculations, the class intervals were determined as follows:

Table 3. NG Class, interval & frequency

NG Class	Interval	Frequency
1	6 – 17	8
2	18 – 29	6
3	30 – 41	7
4	42 – 53	3
5	54 – 65	2
6	66 – 79	2

This table was used as the basis for constructing the histogram.

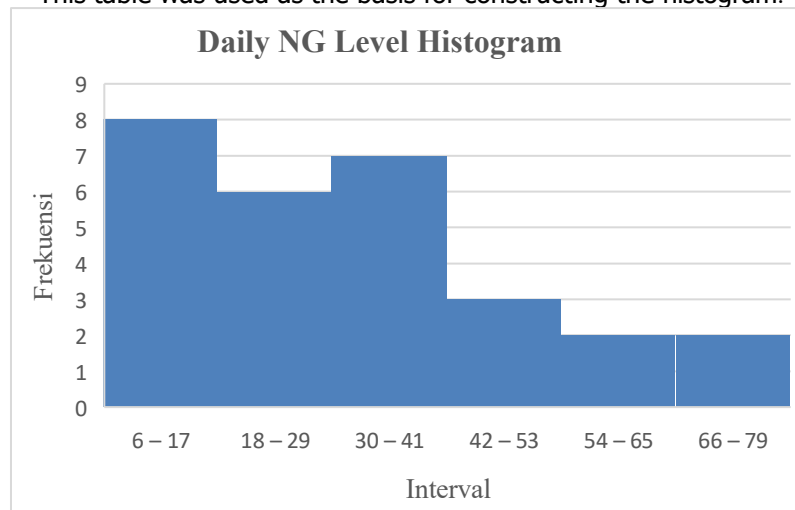


Figure 2. Daily NG Level Histogram

Based on the resulting histogram, it can be observed that the highest frequency of daily NG occurrences falls within the interval of 6–17 units, appearing on 8 days. The next relatively dominant intervals are 30–41 units, which occurred on 7 days, and 18–29 units, which appeared on 6 days. Meanwhile, intervals with relatively high NG counts, namely 54–65 units and 66–79 units, show the lowest frequencies, each occurring on only 2 days.

Data Stratification Based on Time

Subsequently, data stratification was performed to separate production data based on working time in order to analyze defect patterns more specifically. This grouping resulted in two separate datasets, namely production data for Shift 1 and Shift 2. Each dataset contains information on production dates, the number of units produced, the number of NG products, types of NG, and the duration of operating hours for each shift.

Table 4. Stratification Shift 1

Shift 1 (Morning Shift)										
Date	Operatio nal Hours (Hour)	Product ion (pcs)	Total OK (pcs)	Kind of NG						Tot al NG (pc s)
				AM P (pc s)	SHO T (pcs)	SILVE R (pcs)	BLAC K DOT (pcs)	JETTI NG (pcs)	CLOU DY (pcs)	
2	11	1.002	985	0	1	11	0	5	0	17
3	11	1.003	985	0	0	15	0	3	0	18
4	11	912	900	0	0	10	2	0	0	12
6	11	870	830	0	0	8	10	22	0	40
7	4	345	340	0	0	1	0	4	0	5
8	4	345	340	0	0	0	3	2	0	5
9	11	911	900	0	0	5	2	4	0	11
10	8	773	765	0	0	4	1	3	0	8
13	8	690	680	0	0	9	1	0	0	10
14	2	177	170	0	0	7	0	0	0	7
16	8	696	680	6	0	10	0	0	0	16
17	11	914	900	0	0	12	2	0	0	14
18	11	915	900	0	0	14	1	0	0	15
20	10	805	800	4	0	1	0	0	0	5
21	11	752	710	2	2	8	6	24	0	42
22	11	920	900	0	0	6	5	9	0	20
23	11	866	850	0	0	6	5	5	0	16
25	4	320	300	0	0	20	0	0	0	20
26	8	666	645	2	2	8	2	7	0	21
27	11	917	900	0	0	17	0	0	0	17
28	11	917	900	0	0	17	0	0	0	17
29	11	996	980	0	0	16	0	0	0	16
30	8	691	680	0	0	11	0	0	0	11
31	11	1.000	985	0	0	15	0	0	0	15
Total		18.403	18.025	14	5	231	40	88	0	378

Table 5. Stratifikacion Shift 2

Shift 2 (Night Shift)										
Date	Operatio nal Hours (Hour)	Produc tion (pcs)	Total OK (pcs)	Kind of NG						Tot al NG (pc s)
				AM P (pc s)	SHO T (pc s)	SILVE R (pcs)	BLAC K DOT (pcs)	JETTI NG (pcs)	CLOU DY (pcs)	
1	11	827	810	0	0	8	6	0	3	17
2	11	1.005	985	0	0	6	6	8	0	20
3	11	883	835	0	1	10	10	27	0	48
4	11	860	830	4	2	8	6	10	0	30
5	11	923	900	0	0	15	0	8	0	23
6	11	912	900	0	2	9	1	0	0	12
7	7	568	560	0	0	8	0	0	0	8
8	10	824	815	0	7	0	2	0	0	9
9	11	909	900	0	0	9	0	0	0	9
12	10	814	808	4	2	0	0	0	0	6
13	11	858	830	2	2	8	3	13	0	28
16	11	843	780	4	2	8	6	43	0	63
17	8	660	650	0	0	3	2	5	0	10
20	8	694	680	0	0	14	0	0	0	14
21	11	915	900	0	0	15	0	0	0	15
22	11	915	900	0	0	15	0	0	0	15
23	8	694	680	0	0	14	0	0	0	14
24	7	614	600	0	0	14	0	0	0	14
25	8	695	680	0	0	15	0	0	0	15
27	11	874	860	3	0	11	0	0	0	14
28	11	580	540	0	0	11	0	29	0	40
29	10	828	815	0	0	13	0	0	0	13
30	8	665	645	2	2	7	4	5	0	20
31	11	727	700	3	0	13	0	11	0	27
Total		19.087	18.603	22	20	234	46	159	3	484

The results of this stratification will be further analyzed using Pareto diagrams, P control charts, and scatter diagrams.

Pareto Diagram (Pareto Chart)

The next step involved constructing Pareto charts for each shift. The purpose of the Pareto chart is to identify which NG types contribute the most to the total NG occurrences in each shift, thereby enabling the determination of improvement priorities that have the greatest impact on enhancing visor product quality. The frequency of each NG type is arranged from the highest to the lowest, followed by the calculation of the percentage contribution of each NG type.

The percentage of NG for each defect type is calculated using the following formula:

$$\text{Persentase NG} = \frac{\text{Frekuensi NG}}{\text{Total frekuensi NG}} \times 100\%$$

Based on the formula above, the following calculations present the percentage of each NG type for Shift 1 and Shift 2:

A. Shift 1

1. AMP:

$$\text{Persentase NG} = \frac{14}{378} \times 100\% = 4\%$$

2. Shot:

$$\text{Persentase NG} = \frac{5}{378} \times 100\% = 1\%$$

3. Silver:

$$\text{Persentase NG} = \frac{231}{378} \times 100\% = 61\%$$

4. Blackdot:

$$\text{Persentase NG} = \frac{40}{378} \times 100\% = 11\%$$

5. Jetting:

$$\text{Persentase NG} = \frac{88}{378} \times 100\% = 23\%$$

6. Cloudy:

$$\text{Persentase NG} = \frac{0}{0} \times 100\% = 0\%$$

The following table presents the results of the percentage calculations for each NG type in Shift 1, arranged in descending order from the highest to the lowest:

Table 6. Kind, frequency, & persentase of NG shift 1

Kind of NG	Frequency of NG	Persentase NG	Cumulative
SILVER	231	61%	61%
JETTING	88	23%	84%
BLACK DOT	40	11%	95%
AMP	14	4%	99%
SHOT	5	1%	100%
CLOUDY	0	0%	100%
Total	378	100%	

B. Shift 2

1. AMP:

$$\text{Persentase NG} = \frac{22}{484} \times 100\% = 5\%$$

2. Shot:

$$\text{Persentase NG} = \frac{20}{484} \times 100\% = 4\%$$

3. Silver:

$$\text{Persentase NG} = \frac{234}{484} \times 100\% = 48\%$$

4. Blackdot:

$$\text{Persentase NG} = \frac{46}{484} \times 100\% = 10\%$$

5. Jetting:

$$\text{Persentase NG} = \frac{159}{484} \times 100\% = 33\%$$

6. Cloudy:

$$\text{Persentase NG} = \frac{3}{484} \times 100\% = 1\%$$

The following table presents the results of the percentage calculations for each NG type in Shift 2 after being arranged from the highest to the lowest:

Tabel 7. Jenis, frekuensi, & persentase NG shift 2

Kind of NG	Frequency of NG	Persentase NG	Cumulative
SILVER	234	48%	48%
JETTING	159	33%	81%
BLACK DOT	46	10%	91%
AMP	22	5%	95%
SHOT	20	4%	99%
CLOUDY	3	1%	100%
Total	484	100%	

After determining the percentage of each NG type for both shifts, the results are then visualized in the form of bar charts accompanied by cumulative percentage lines. The following figures present the Pareto charts for Shift 1 and Shift 2:

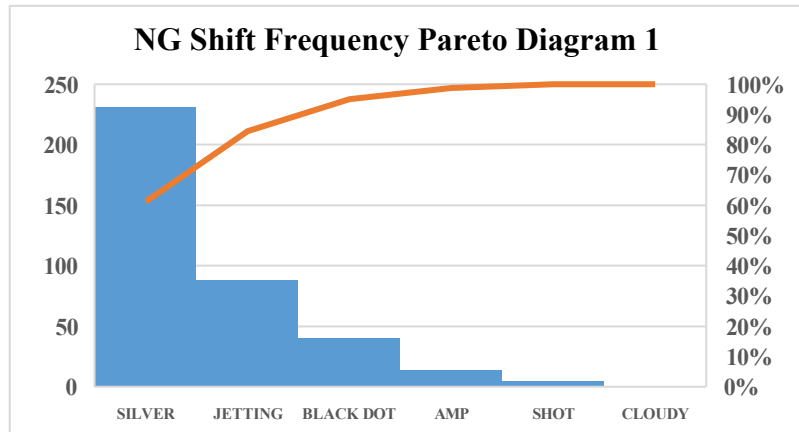


Figure 3. NG Shift Frequency Pareto Diagram 1

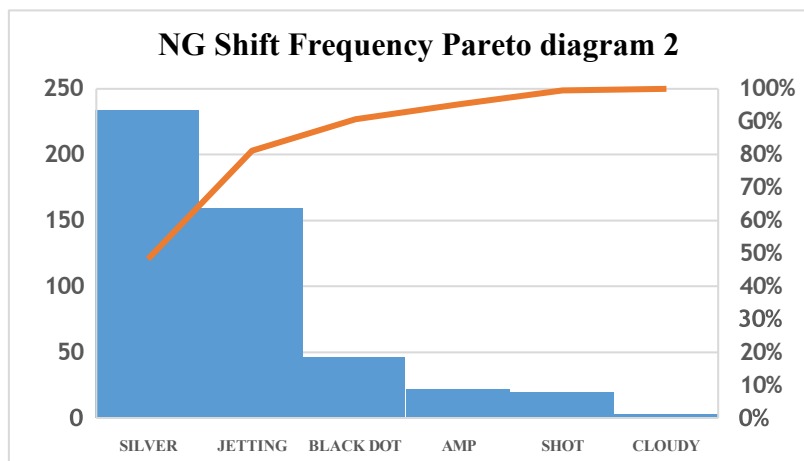


Figure 4. NG Shift Frequency Pareto diagram 2

In Shift 1, Silver defects (61%) and Jetting defects (23%) together account for a cumulative contribution of 84% of the total NG occurrences. Similarly, in Shift 2, Silver defects (48%) and Jetting defects (33%) also dominate, with a cumulative contribution of 81%.

These findings indicate that quality issues in both shifts primarily originate from these two NG types. Therefore, improvement efforts are focused on Silver and Jetting defects, as addressing these two critical areas is expected to provide the greatest impact in reducing the overall NG rate.

Analysis of NG Proportion Stability Using the P Control Chart

The stability analysis of the NG product proportion was conducted using a P control chart as one of the tools within the Seven Quality Tools framework. This control chart was applied to evaluate whether the proportion of NG products produced during each production period or shift was statistically under control.

The calculation of the NG proportion and the determination of the upper control limit (UCL), center line (CL), and lower control limit (LCL) were based on data on total production and NG quantities for each subgroup. All calculation steps are presented in detail in the Appendix, while the discussion in this section focuses on the results and interpretation of the control chart.

The following table presents the results of the calculations for the NG proportion, upper control limit (UCL), center line (CL), and lower control limit (LCL) for Shift 1 and Shift 2:

Table 8. Results of CL, UCL, and LCL calculations for shift 1

Shift 1 (Morning Shift)							
Subgroup	Date	Production Frequency	Frequency NG	Proportion NG	UCL	CL	LCL
1	2	1.002	17	0,01697	0,03398	0,02054	0,00710
2	3	1.003	18	0,01795	0,03398	0,02054	0,00710
3	4	912	12	0,01316	0,03463	0,02054	0,00645
4	6	870	40	0,04598	0,03497	0,02054	0,00611
5	7	345	5	0,01449	0,04345	0,02054	0,00000
6	8	345	5	0,01449	0,04345	0,02054	0,00000
7	9	911	11	0,01207	0,03464	0,02054	0,00644
8	10	773	8	0,01035	0,03584	0,02054	0,00524
9	13	690	10	0,01449	0,03674	0,02054	0,00434
10	14	177	7	0,03955	0,05252	0,02054	0,00000
11	16	696	16	0,02299	0,03667	0,02054	0,00441
12	17	914	14	0,01532	0,03461	0,02054	0,00647
13	18	915	15	0,01639	0,03461	0,02054	0,00647
14	20	805	5	0,00621	0,03554	0,02054	0,00554
15	21	752	42	0,05585	0,03606	0,02054	0,00502
16	22	920	20	0,02174	0,03457	0,02054	0,00651
17	23	866	16	0,01848	0,03500	0,02054	0,00608
18	25	320	20	0,06250	0,04433	0,02054	0,00000
19	26	666	21	0,03153	0,03703	0,02054	0,00405
20	27	917	17	0,01854	0,03459	0,02054	0,00649
21	28	917	17	0,01854	0,03459	0,02054	0,00649
22	29	996	16	0,01606	0,03402	0,02054	0,00706
23	30	691	11	0,01592	0,03673	0,02054	0,00435
24	31	1.000	15	0,01500	0,03400	0,02054	0,00708
Total		18.403	378				

Table 9. Results of CL, UCL, and LCL calculations for shift 2

Shift 2 (Shift Malam)							
Subgroup	Date	Production Frequency	Frequency of NG	Proportion NG	UCL	CL	LCL
1	1	827	17	0,02056	0,04176	0,02536	0,00896
2	2	1.005	20	0,01990	0,04023	0,02536	0,01048

3	3	883	48	0,05436	0,04123	0,02536	0,00949
4	4	860	30	0,03488	0,04144	0,02536	0,00928
5	5	923	23	0,02492	0,04088	0,02536	0,00983
6	6	912	12	0,01316	0,04097	0,02536	0,00974
7	7	568	8	0,01408	0,04515	0,02536	0,00557
8	8	824	9	0,01092	0,04179	0,02536	0,00893
9	9	909	9	0,00990	0,04100	0,02536	0,00971
10	12	814	6	0,00737	0,04189	0,02536	0,00883
11	13	858	28	0,03263	0,04146	0,02536	0,00926
12	16	843	63	0,07473	0,04160	0,02536	0,00911
13	17	660	10	0,01515	0,04372	0,02536	0,00700
14	20	694	14	0,02017	0,04326	0,02536	0,00745
15	21	915	15	0,01639	0,04095	0,02536	0,00977
16	22	915	15	0,01639	0,04095	0,02536	0,00977
17	23	694	14	0,02017	0,04326	0,02536	0,00745
18	24	614	14	0,02280	0,04439	0,02536	0,00632
19	25	695	15	0,02158	0,04325	0,02536	0,00747
20	27	874	14	0,01602	0,04131	0,02536	0,00940
21	28	580	40	0,06897	0,04494	0,02536	0,00577
22	29	828	13	0,01570	0,04175	0,02536	0,00897
23	30	665	20	0,03008	0,04365	0,02536	0,00707
24	31	727	27	0,03714	0,04285	0,02536	0,00787
Total		19.087	484				

Based on the calculation results presented in the table above, the following figures show the P control charts (P-Charts) for the NG proportions observed during each production period, namely Shift 1 and Shift 2

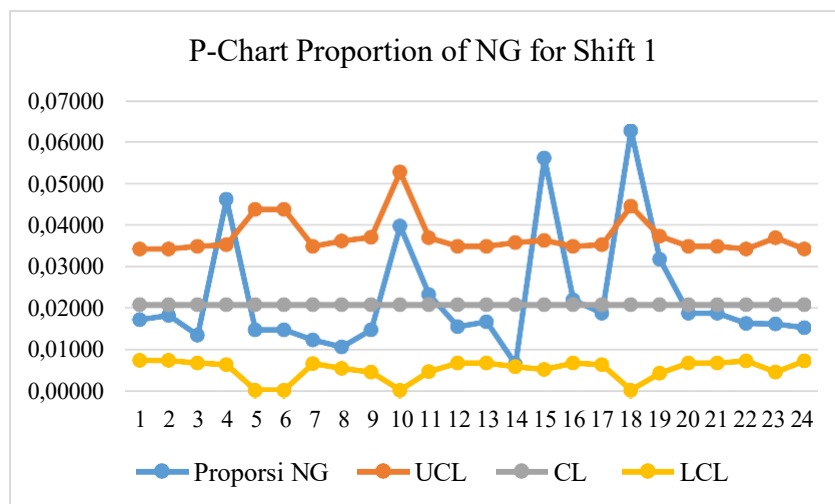


Figure 5. P-Chart proportion NG for shift 1

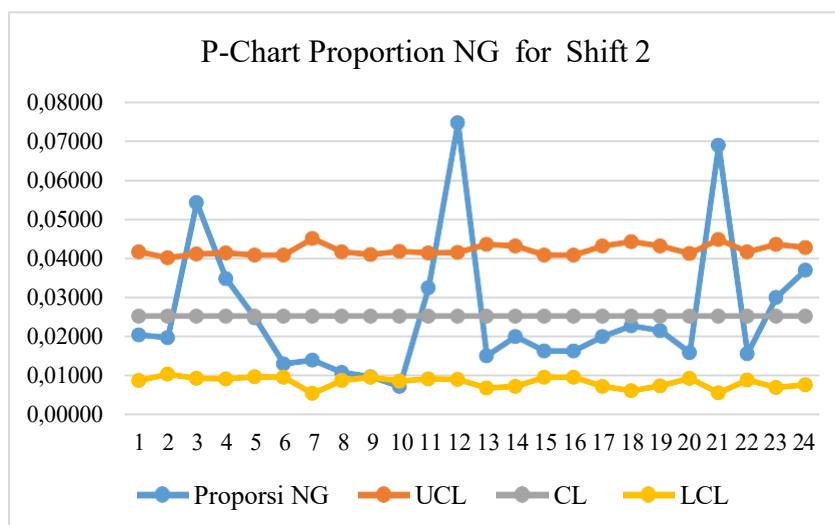


Figure 6. P-Chart proportion NG for shift 2

Based on the calculation results, the center line (CL) value for Shift 1 is 0.02054. The majority of NG proportion points fall within the control limits, indicating that the process is generally influenced by common cause variation. However, three subgroups are observed to fall above the upper control limit (UCL), namely:

1. Subgroup 4 (Date 6)
2. Subgroup 15 (Date 21)
3. Subgroup 18 (Date 25)

These three points indicate the presence of special cause variation, suggesting abnormal conditions on those particular days, such as improper machine settings, material contamination, or other process disturbances. Therefore, the Shift 1 process cannot be considered fully stable.

P-Chart Results for Shift 2

For Shift 2, the center line (CL) value is 0.02536. The pattern of points shows several observations approaching the upper control limit (UCL), and three subgroups exceed the UCL, namely Subgroup 3 (Date 3), Subgroup 12 (Date 16), and Subgroup 21 (Date 28). Subgroups 12 and 21 exhibit the highest NG proportions in the entire dataset, indicating strong special cause variation. This suggests that significant process disturbances occurred on those dates, such as issues related to material quality, changes in machine parameters, or specific operational conditions. Consequently, the Shift 2 process is also not yet in a statistically stable condition.

Scatter Diagram Analysis

A scatter diagram is used to examine the relationship between two variables that are presumed to influence each other in the production process. In this study, scatter diagrams were developed to analyze whether there is a relationship between operational hours per shift and the number of non-good (NG) products. The use of scatter diagrams is relevant because changes in operational duration are often associated with operator fatigue, variations in workload, and the stability of process performance. The variables analyzed are as follows:

A. **X variable (independent):** Operational hours per shift

B. **Y variable (dependent):** Frequency of NG per shift

The analysis was conducted separately for Shift 1 and Shift 2 to allow clearer observation of relationship patterns within each shift.

A. Scatter Diagram – Shift 1

In Shift 1, the X variable (operational hours) was recorded within a range of 2 to 11 hours, while the Y variable (NG frequency) ranged from 5 to 42 NG units. Most of the observed data points were concentrated within normal operational hours (8–11 hours), although several days exhibited shorter operational durations.

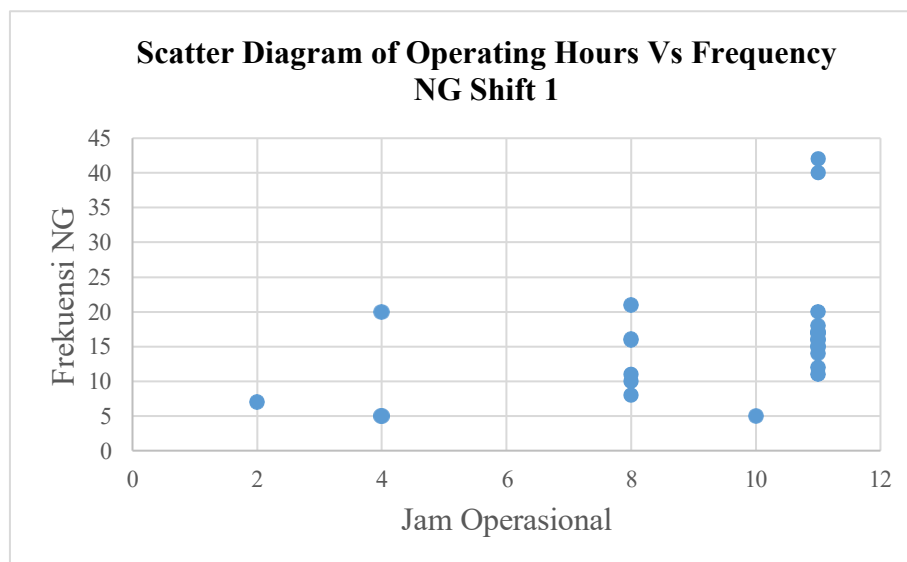


Figure 8. Scatter Diagram of Operating Hours Vs Frequency NG Shift 1

The distribution of data points indicates that:

1. There is no consistent relationship pattern between operational hours and the number of NG products.
2. At 11 hours of operation, the NG frequency can be either very low (11–17 units) or very high (40–42 units).

3. At 4 operational hours, the NG level is low (5 units), whereas at 8 operational hours, the NG frequency can be low or even higher (8–21 units).
4. The data points are randomly scattered with no clear upward or downward trend.

Based on the scatter pattern, the X variable does not show a significant influence on the Y variable for Shift 1. In other words, operational hours do not have a significant relationship with the NG rate. Variations in NG are more likely caused by process-related factors such as machine condition, material quality, and the working environment.

B. Scatter Diagram for Shift 2

In Shift 2, the X variable (operational hours) ranges from 7 to 11 hours, while the Y variable (NG frequency) varies between 6 and 63 NG units. Notably, the highest NG values occur during standard operational hours (11 hours).

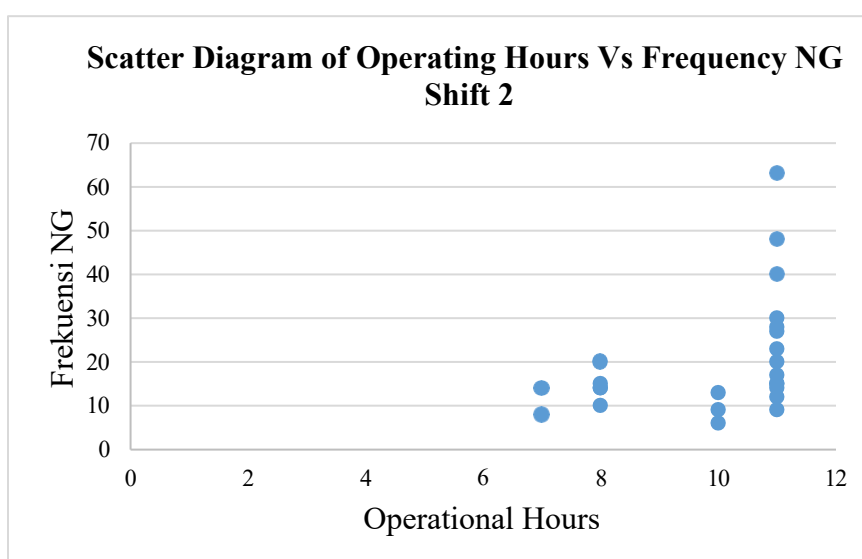


Figure 9. Scatter Diagram of Operating Hours Vs Frequency NG Shift 2

The observations indicate that:

1. There is no indication of a linear relationship between variables X and Y.
2. At 11 operational hours, the NG quantity can be low (9–15 units) or extremely high (40–63 units).
3. At 8 operational hours, the NG frequency shows a relatively wide range (10–20 units).
4. The data points are randomly distributed without any specific pattern.

The scatter diagram for Shift 2 demonstrates that operational hours per shift are not correlated with NG frequency. High NG values at several data points occur during normal working hours; therefore, it can be concluded that variable X does not influence variable Y.

Root Cause Analysis Using a Fishbone Diagram

After prioritizing NG types using the Pareto diagram, it was found that Silver and Jetting defects were the most dominant NG types, accounting for a cumulative contribution of 84% in the morning shift and 81% in the night shift. In addition, the results of the p-control chart revealed several observation points that exceeded the control limits, indicating the presence of special cause variation during certain periods. These findings further reinforce the need for a comprehensive root cause analysis.

A. Fishbone Analysis of Silver Defects

Silver defects typically appear on the product surface as a result of unstable material flow, contamination, or excessive material moisture. Referring to the actual production conditions, the potential causes of Silver defects can be explained as follows:

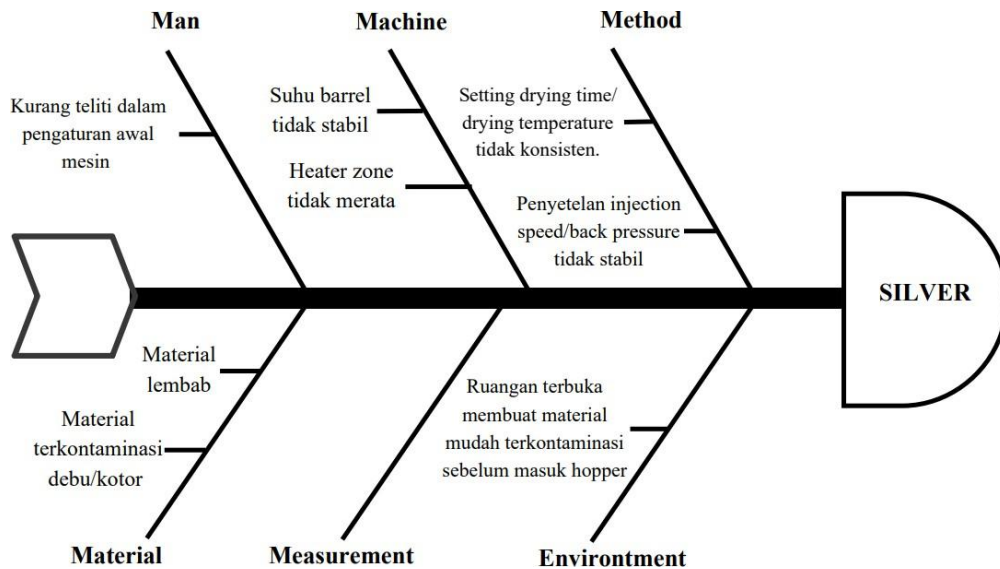


Figure 10. Fishbone Diagram for NG Silver

Silver defects are characterized by the appearance of silvery streaks on the surface of visor products.

B. Fishbone NG Jetting

Jetting defects occur due to excessively fast or unstable material flow as it enters the mold. Based on actual conditions at PT. SPI, the causes can be explained as follows:

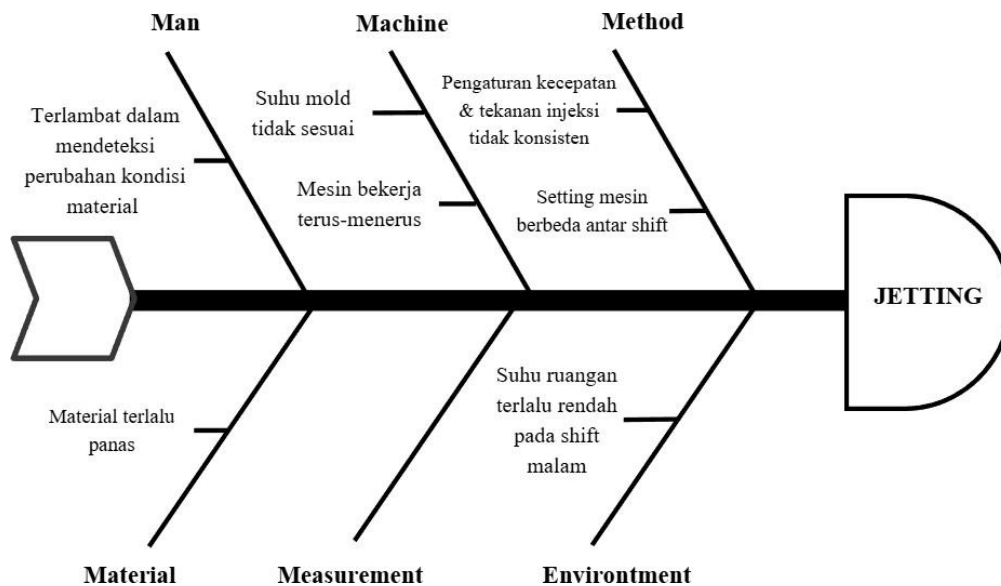


Figure 11. Fishbone Diagram for NG Jetting

Jetting defects are characterized by wavy flow patterns or snake-like marks on the product surface, particularly in areas near the gate.

In the fishbone diagram analysis process, causal data were obtained from indicators representing the actual conditions observed on the shop floor during the production process. The assessment of the level of influence of each causal factor on the occurrence of defects in visor products was carried out through a scoring process based on field observations and on-site confirmation. This scoring was intended to evaluate the relative contribution of each potential cause to the occurrence of dominant defects using a semi-quantitative approach.

1. Scoring Contributors

Scores were assigned by the analyst based on direct observations conducted over approximately 20 days in the visor production area at PT. Solo Plastik Indonesia, as well as through discussions and validation with relevant stakeholders, namely:

- a) Production supervisors
- b) Injection molding machine operators (Shift 1 and Shift 2)
- c) Quality Control (QC) staff

The involvement of these three parties was intended to minimize assessment subjectivity, as each possesses direct experience in addressing process-related issues and quality inspection activities.

2. Assessment Basis

The basis for score assignment referred to the frequency of occurrences observed during the study period. Table X presents the scoring criteria for each indicator identified under actual shop-floor conditions.

Table 10. Assessment criteria

Score	Frequency Category	Criteria
1	Very Rarely	1–5 Occurrence
2	Rarely	6–10 Occurrence
3	Rarely enough	11–15 Occurrence
4	Frequently	16–20 Occurrence
5	Very Frequently	> 20 Occurrence

Based on these assessment criteria, Table X presents the evaluation of indicators associated with the causes of Silver and Jetting defects in visor products :

Table 11. Indicators causing NG silver & jetting

Faktor	Penyebab	Indikator	Skala Penilaian	Akibat
Man	Lack of care in initial machine settings	The initial machine settings were not rechecked.	1	Silver
		Operator does not use machine setting checklist	3	
	Delay in detecting changes in material conditions	Changes in material texture are not immediately followed up	2	Jetting
Machine	Barrel temperature is unstable	Temperature fluctuations occur on the machine's control panel.	4	Silver
	Uneven heater zone	Temperature difference between heater zones	5	Silver

	Mold temperature is not appropriate	Mold temperature is outside process standards	5	Jetting
	The machine works continuously	Long engine operating time without cooling breaks	4	Jetting
Method	Setting drying time / drying temperature is inconsistent	Drying time and temperature standards are less accurate	3	Silver
		Drying settings change frequently	3	
	Injection speed / back pressure adjustment is unstable	The injection speed value is often changed	4	Silver
		Back pressure does not refer to standard parameters	3	
	Inconsistent injection speed and pressure settings	Injection speed and pressure values are less accurate	4	Jetting
	Machine settings vary between shifts	There is no standard setting for shift 1 and shift 2.	3	Jetting
		The operator performs a reset	4	
Material	Damp material	Storage of materials in humid conditions	2	Silver
		Material drying is not optimal	5	
		Uneven material texture	4	
	Material contaminated with dust/dirt	The material is left open before entering the hopper.	5	Silver
		Material packaging is not closed	5	
	Material is too hot	Overheating of the material occurs during the melting process	4	Jetting
Environment	Open spaces cause materials to be easily contaminated	Unenclosed material storage area	4	Silver
		Material is exposed to dust before entering the hopper	3	
Measurement	No significant cause found	There was no indication of measurement error during the observation.	–	–

From the table above, the total score for each factor can be seen as follows:

1. Man = 6
2. Machine = 18
3. Material = 25
4. Method = 24
5. Environment = 7
6. Measurement = 0

Total skor = 80

ubsequently, the scores were normalized by performing calculations to determine the percentage contribution of each causal factor to the occurrence of dominant NG defects, using the following formula:

$$\text{Percentase factor} = \frac{\text{Total score factor}}{\text{Total all of score}} \times 100\%$$

Using the formula above, the calculation for each factor is as follows:

1. Man:

$$\text{Percentage factor} = \frac{6}{80} \times 100\% = 7,5\%$$

The human factor only contributed 7.5% of the total assessment scale score, being the lowest among the other factors.

2. Machine:

$$\text{Percentage factor} = \frac{18}{80} \times 100\% = 22,5\%$$

The machine factor contributes 22.5% and is in third place of all factors.

3. Material:

$$\text{Percentage factor} = \frac{25}{80} \times 100\% = 31,25\%$$

Material factors are the most contributing factors with a percentage of 31.25% of the total assessment scale score.

4. Method:

$$\text{Percentage factor} = \frac{24}{80} \times 100\% = 30\%$$

The method factor is in second place with a percentage of 30%.

5. Environment:

$$\text{Percentage factor} = \frac{7}{80} \times 100\% = 8,75\%$$

Environmental factors are in second lowest place, contributing 8.75%.

Conclusion

Based on the processing and analysis of visor production quality data during October 2025 at PT. Solo Plastik Indonesia, several conclusions can be drawn as follows.

The quality condition of visor products during the observation period shows a total production of 37,490 units, with 862 units classified as No Good (NG), resulting in an average NG rate of 2.3% of total production. The types of NG identified include Silver, Jetting, Black Dot, Short Shot, AMP, and Cloudy. These findings provided the basis for the application of the Seven Quality Tools analysis.

The implementation of the Seven Quality Tools in this study was conducted to systematically analyze product quality control. Through the Checksheet, daily data on the number and types of NG were collected as the foundation for analysis. The data were then stratified according to production time, i.e., Shift 1 and Shift 2. The Histogram illustrated the fluctuating distribution of daily NG frequency, while the Pareto Diagram identified that Silver and Jetting were the two dominant NG types, contributing 84% in Shift 1 and 81% in Shift 2. The p-control chart (p-chart) analysis indicated that the production processes in both shifts were not yet fully statistically controlled, as several data points exceeded the control limits. The Scatter Diagram showed no significant relationship between operational hours and the number of NG products produced.

Subsequently, the Fishbone Diagram was used to trace the root causes of NG, revealing that the dominant factors affecting quality were Material (31.25%), followed by Method (30%), Machine (22.5%), Environment (8.75%), and Man (7.5%).

The most frequently occurring NG types were Silver and Jetting, accounting for over 80% of total NG. Silver defects were generally caused by Material factors, such as moist material, contamination by dust or dirt, and suboptimal drying processes. Meanwhile, Jetting defects were primarily influenced by Method and Machine factors, including inconsistent injection pressure and speed settings, as well as differences in parameter settings between shifts that led to process instability. Overall, the three main factors—Material, Method, and Machine—contributed 84% to the occurrence of NG products, making them the primary priorities for quality improvement efforts in visor production at PT. Solo Plastik Indonesia.

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