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ADMI Jurnal Ilmiah Teknik

JUIT Vol AA No. AA | Month 2026 | ISSN: 2828-6936 (Print), ISSN: 2828-6901 (online), Page. AA-AA

Quality Control of Plastic Pallet Products on the Sound 1800 Machine to Reduce Rejection: A Case Study at PT. Group Cemerlang Plastindo

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Article History
Received :
Accepted :
Published :
Available Online:

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Cite This Article:

DOI:

Abstract: PT Group Cemerlang Plastindo is a plastic pallet manufacturing company that continues to encounter a high number of rejected products in its production process using the Sound 1800 machine. This problem has resulted in decreased product quality, increased material waste, and reduced production process efficiency. This study aims to identify the dominant types of rejects, analyze the factors causing product defects, and determine the optimal combination of process parameters to reduce the reject rate of plastic pallets. The method employed in this study is the Taguchi method, supported by quality control tools, including check sheets, histograms, Pareto diagrams, control charts, and fishbone diagrams. The research data were obtained from production records from January 2025 to January 2026, as well as from observations and interviews conducted in the production department. The results show that, out of a total production of 107,669 units, 2,499 units were rejected, with the dominant defect types consisting of 998 short shot defects, 708 discoloration defects, and 505 crack defects. The optimization results using the Taguchi method indicate that process parameter adjustment reduced the number of rejected products from 383 units to 332 units, representing a 0.39% reduction in the reject ratio. The implications of this study suggest that quality control based on the Taguchi method can assist the company in determining more stable production parameters, reducing waste, and improving product quality consistency. The originality of this study lies in the specific application of a combined Taguchi method and quality control tools to the production of plastic pallets on the Sound 1800 machine, with a focus on the three dominant types of rejects.

Keywords: Fishbone Diagram; Injection Molding; Taguchi Method; Plastic Pallet; Quality Control.

INTRODUCTION

The development of the manufacturing industry requires companies to be able to produce high-quality products that meet customer expectations. The capabilities of a company's human resources can be significantly improved through the production of high-quality goods; however, the company's success is primarily determined by the quality of the products it produces. Effective quality control requires quality monitoring costs to ensure that the products produced remain in accordance with company standards (F. A. Lestari & Purwatmini, 2021). If quality control is not properly implemented, the company will face difficulties in marketing its products due to competition with similar products of higher quality, as well as an increase in the number of rejected products that may cause losses to the company.

PT. Group Cemerlang Plastindo is a company engaged in the production of plastic pallets located in Tanggulangin, Sidoarjo. The company has a quality policy to produce the best products carefully and efficiently in order to meet customer needs and continuously improve company performance. In its production process, plastic pallets are manufactured using several machines that operate 24 hours a day. The production process begins with the mixing of HDPE (High-Density Polyethylene) or PP (Polypropylene) plastic pellets with additional materials such as colorants and UV stabilizers. The material is then heated until it melts inside the injection molding machine and is injected into the mold under high pressure. After the cooling process is completed, the product enters the finishing and quality inspection stages before being delivered to customers.

However, various product quality problems that lead to rejection are still found in the production process. The Sound 1800 machine, which is used continuously, has the potential to experience operational disturbances, resulting in product defects such as short shots, cracks, uneven coloring, and dimensional nonconformities. In addition to machine-related factors, rejected products may also be influenced by operator errors and inaccuracies in raw material measurement. The company establishes quality standards that include measurable aspects such as dimensions, product weight, and warping, as well as visual quality standards such as pallet color, flash, short shots, and cracks to maintain consistency in product quality.

Based on production data from January 2025 to January 2026, the rejection rate of the Sound 1800 machine continued to fluctuate and several times exceeded the company's tolerance limit of 2%. The highest rejection percentage occurred in January 2025, at 2.95%, while the lowest percentage occurred in December 2025, at 1.68%. However, in January 2026, the rejection percentage increased again to 2.24%. This condition indicates that the production process remains vulnerable to variations in both technical and environmental factors. A high production volume does not necessarily guarantee a low rejection rate, as there is an interaction among process parameters such as temperature, injection pressure, and cooling time that has not yet reached optimal conditions.

Data on rejection types indicate that short shots, uneven coloring, and cracks were the most dominant types of defects in each production period. The occurrence of these rejection types indicates inaccuracies in the adjustment of production process parameters, particularly machine temperature, injection pressure, and cooling time. The repeated high occurrence of short shots, uneven coloring, and cracks shows that the machine parameter settings have not been able to produce a stable process that is resistant to disturbance factors. Therefore, a method is required to determine the optimal combination of process parameters in order to reduce the product rejection rate.

One method that can be used is the Taguchi method. The Taguchi method is a quality control method that aims to improve product quality by minimizing process variation and producing process parameters that are robust against disturbance factors. In this study, the Taguchi method is supported by the use of quality control tools such as check sheets, histograms, Pareto diagrams, fishbone diagrams, and control charts. The Pareto diagram is used to identify dominant rejection types, while the fishbone diagram is used to analyze the root causes of product defects based on human, machine, method, material, and work environment factors. The process parameters used in this study include the production machine temperature, pressure or pressing duration of 20–50 seconds, and cooling time of 1–2.5 minutes (Ramadhan & Bisono, 2024).

Based on these problems, this study was conducted to determine the most optimal combination of process parameters for reducing the rejection rate of plastic pallet products on the Sound 1800 machine at PT. Group Cemerlang Plastindo. Through the application of the Taguchi method, the company is expected to improve product quality, reduce the rejection rate, and achieve a more stable and efficient production process (Yuliana, 2021).

RESEARCH METHOD

This study was conducted at PT. Group Cemerlang Plastindo, located in Tanggulangin, Sidoarjo, with a research focus on quality control of plastic pallet products on the Sound 1800 machine using the Taguchi method. The Taguchi method was used as a quality control approach to determine the optimal combination of process parameters in order to minimize the rate of rejected products and improve the stability of the production process. This approach was selected because it is capable of producing process parameters that are robust against disturbance factors and is more efficient in experimental implementation.

The initial stage of the study was carried out through direct observation in the plastic pallet production area to understand the production process flow and identify quality problems that occurred during the production process. Observations were conducted on machine conditions, production process parameters, and types of product defects that frequently occurred. In addition, a literature review was conducted through journals, books, and previous studies related to quality control, the seven tools, and the Taguchi method as the theoretical basis of the study.

Data collection in this study consisted of primary and secondary data. Primary data were obtained through direct observation, interviews with operators and the production manager, and records of the number of rejected products on the Sound 1800 machine from January 2025 to January 2026. The data collected included production volume, number of rejected products, types of product defects, and production process parameters such as machine temperature, pressing time, and cooling time. Meanwhile, secondary data were obtained from company documents, production reports, company quality standards, and supporting references from journals and scientific books.

The data processing technique in this study was carried out through several stages, as follows:

1. Determination of Product Rejection Factors

By collecting check sheet forms, preparing histograms, Pareto diagrams, and control charts using the company's product rejection data, PT. Group Cemerlang Plastindo was able to identify the variables used in determining parameter settings. To adjust these variables to the existing conditions at PT. Group Cemerlang Plastindo, interviews or question-and-answer sessions were also conducted with the quality control department, in addition to reviewing previous studies.

Table 1. Check Sheet Form

No	Month	Defect Type

Production Quantity (pcs)	Short shot	Uneven Coloring	Crack	Total Defects (pcs)

2. Development of a Cause-and-Effect Diagram

A cause-and-effect diagram consisting of five categories, namely human, material, method, machine, and environment, was developed after the variables had been determined. The purpose of developing the cause-and-effect diagram was to simplify the problem and facilitate the calculation process for parameter determination.

3. Experiment Using the Taguchi Method

a. Determination of the Dependent Variable

The dependent variables in this study include uneven coloring and short shots at PT. Group Cemerlang Plastindo. The criterion used is “smaller the better,” which means that reducing the number of defective products will improve quality.

b. Identification of Factors (Independent Variables)

This study uses machine temperature, molding time, and cooling time as independent variables. In this experiment, machine temperature, pressing time, and cooling time are isolated as control parameters. Weather conditions and room temperature are considered noise factors.

c. Determination of the Number of Levels and Factor Level Values

Three experimental levels were used for the following variables in this study:

Table 2. Design of Factor Values at Levels 1 to 3

No.	**Notation**	**Factor**	**Level 1**	**Level 2**	**Level 3**
1	A	Production machine temperature	180°	200°	220°
2	B	Pressing time	20 seconds	35 seconds	50 seconds
3	C	Cooling time	1 minute	1.5 minutes	2.5 minutes

4. Calculation of Degrees of Freedom

The minimum number of experiments required to test the observable variables was calculated using degrees of freedom.

$$\text{Dof} = nA - 1 \quad (1)$$

5. Selection of the Orthogonal Array

An equation describing the number of elements, levels, and observations conducted is required to select the appropriate orthogonal array.

$$\text{Derajat bebas matriks} = \text{jumlah faktor x (jumlah level-1)} \quad (2)$$

6. Preparation for Experimental Implementation

Determining the number of replications and designing a randomized experimental design are two aspects involved in experimental preparation.

7. Data Analysis

Data processing includes data collection, calculation, and presentation. In addition, formulas were applied to the experimental data to perform data calculations and evaluation. The signal-to-noise (S/N) ratio approach and the calculation of main effects were used in data processing.

$$S/N = -10 \log \frac{1}{N} \Sigma_{i=1}^{q} \Sigma_{j=1}^{j} \Sigma_{k=1}^{N} (yijk)^2 \quad (3)$$

8. Analysis of Variance (ANOVA)

Analysis of variance is a technique used to determine the number of degrees of freedom in an experiment by decomposing variance into different sources of variation. The calculated data include the overall experimental mean, total sum of squares, mean sum of squares, sum of squares for each factor level, degrees of freedom, mean square, error sum of squares, factor pooling, F-ratio, pure sum of squares, and percentage contribution.

9. Confirmation Experiment

The confirmation experiment includes the results obtained from the previous data analysis. The purpose of this experiment is to identify the ideal parameter settings.

RESULT AND DISCUSSION

This study aims to analyze the causes of rejected products in the plastic pallet production process at PT. Group Cemerlang Plastindo using the Taguchi method. This method is used to identify the factors that affect product quality and to determine the optimal combination of process parameters for reducing the rejection rate on the Sound 1800 machine. The following presents the results and discussion for each stage of the study.

Identification of Product Rejection Data

The initial stage of the study was conducted by identifying the number of rejected plastic pallet products on the Sound 1800 machine from January 2025 to January 2026. Rejection data were obtained from the company's production records, which showed that the rejection rate still fluctuated and several times exceeded the company's tolerance limit of 2%.

Table 3. Rejection Percentage of the Sound 1800 Machine

Month	Production Quantity (pcs)	Rejected Products (pcs)	Rejection Percentage
January 2025	8,089	239	2.95%
February 2025	7,855	215	2.74%
March 2025	8,275	210	2.53%
April 2025	8,230	207	2.52%
May 2025	8,229	212	2.58%
June 2025	8,305	193	2.32%
July 2025	8,570	207	2.42%
August 2025	8,709	211	2.42%
September 2025	8,997	198	2.20%
October 2025	9,075	175	1.93%
November 2025	9,093	163	1.79%
December 2025	8,849	149	1.68%
January 2026	5,393	121	2.24%

Based on Table 3, the highest rejection percentage occurred in January 2025, at 2.95%, while the lowest rejection percentage occurred in December 2025, at 1.68%. However, in January 2026, the rejection percentage increased again to 2.24%. This indicates that the plastic pallet production process on the Sound 1800 machine remains unstable and is influenced by variations in production process parameters as well as work environment factors.

Analysis of Product Rejection Types

The next stage involved identifying the most dominant types of rejection in the plastic pallet production process. The data indicate that several types of rejection occurred during production, namely short shots, uneven coloring, cracks, dimensional errors, over/underweight, warping, and overflow.

Table 4. Total Rejection Types on the Sound 1800 Machine

Rejection Type	Total Rejections (pcs)
Short shot	998
Uneven coloring	708

Crack	505
Dimensional error	59
Over/Underweight	34
Warping	77
Overflow	118

Based on Table 4, short shot was the most dominant type of defect, with a total of 998 pcs, followed by uneven coloring with 708 pcs and cracks with 505 pcs. These three types of rejection were the largest contributors to the total production failures of plastic pallets on the Sound 1800 machine.

Short shot defects occur when molten plastic material does not completely fill the mold cavity. Uneven coloring is caused by non-uniform color distribution during the material mixing and heating process, whereas crack defects occur due to an unstable cooling process, which causes cracks to form in the pallets.

Fishbone Diagram Analysis

The analysis stage was conducted using a fishbone diagram to identify the main factors causing rejected plastic pallet products. The results of the analysis show that the causes of product rejection originate from human, machine, method, material, and environmental factors.

1) Human

   The lack of operator accuracy in setting machine parameters is one of the causes of product rejection. In addition, operators who work continuously experience increased fatigue, which affects their concentration during the production process.

2) Machine

   The Sound 1800 machine, which operates continuously for 24 hours, causes the machine condition to become less stable. Fluctuating heating temperatures and inconsistent injection pressure lead to the occurrence of short shot and uneven coloring defects.

3) Method

   The adjustment of production process parameters is still based on operator experience; therefore, no truly optimal parameter standard has been established. This condition causes the production process to operate inconsistently.

4) Material

The unstable quality of plastic raw materials affects the quality of the plastic pallets produced. The use of recycled material mixtures also causes differences in material characteristics, thereby influencing the quality of the final product.

5) Environment

The production room temperature and work environment conditions affect the stability of the product cooling process. Changes in environmental temperature cause the cooling time to become less optimal and trigger the occurrence of crack defects.

6) Determination of Factors and Levels in the Taguchi Method

Based on the identification of the problems, this study used three main factors in the Taguchi method experiment, namely production machine temperature, pressing time, and cooling time. Each factor consisted of three experimental levels.

Table 5. Experimental Factors and Levels

Factor	**Level 1**	**Level 2**	**Level 3**
Production machine temperature	180°C	200°C	220°C
Pressing time	20 seconds	35 seconds	50 seconds
Cooling time	1 minute	1.5 minutes	2.5 minutes

The determination of factor levels was based on the actual conditions of the production process on the Sound 1800 machine and the results of discussions with operators and the company's quality control department.

Analysis Using Statistical Tools

Based on the calculation results using statistical tools at the check sheet stage, historical data on plastic pallet production for 13 months at PT. Group Cemerlang Plastindo were obtained. The total production of plastic pallets reached 107,669 pcs, with a total of 2,499 rejected products. The types of rejection identified included 998 pcs of short shots, 708 pcs of uneven coloring, 505 pcs of cracks, 59 pcs of dimensional errors, 34 pcs of over/underweight products, 77 pcs of warping, and 118 pcs of overflow.

Table 6. Types of Rejected Plastic Pallet Products

No.	**Type of Rejection**	**Number of Rejections**	**Rejection Percentage**
1	Short shot	998	39.94%
2	Uneven coloring	708	28.33%
3	Crack	505	20.21%

Based on Table 6, short shot, uneven coloring, and crack were the three most dominant types of rejection in plastic pallet production at PT. Group Cemerlang Plastindo.

Short shot had the highest percentage, at 39.94%, followed by uneven coloring at 28.33% and crack at 20.21%.

The histogram and Pareto diagram results indicate that these three types of rejection should be prioritized in product quality improvement because they contributed the most to the total number of product defects.

The next stage was conducted using a control chart to determine the stability of the production process. Based on the control chart calculation results, the rejection data remained within the control limits. This indicates that the production process was still within reasonable control limits; however, the company still needs to improve product quality in order to reduce the rejection percentage as much as possible.

Signal-to-Noise Ratio (S/N Ratio) Analysis

The next stage involved processing the experimental data using the signal-to-noise ratio (S/N ratio) approach with the "smaller-the-better" quality characteristic. This approach was used because the objective of the study was to minimize the number of rejected products.

The analysis results show that production machine temperature had the greatest influence on the quality of plastic pallets. A machine temperature that was too low caused the material to melt incompletely, resulting in short shot defects. Conversely, an excessively high temperature caused product discoloration and triggered uneven coloring defects.

In addition to machine temperature, cooling time also had a significant effect on the occurrence of crack defects. A cooling time that was too short caused the product to crack due to unstable temperature changes. Therefore, an optimal combination of parameters is required so that the production process can operate more stably and produce better product quality.

Analysis of Variance (ANOVA)

Analysis of variance (ANOVA) was conducted to determine the factors that had the greatest influence on the quality of plastic pallet products. The analysis results show that production machine temperature was the dominant factor affecting the product rejection rate, followed by pressing time and cooling time.

Based on the results of the Taguchi method calculations, the optimal parameter combination was obtained at a production machine temperature of 200°C, a pressing time of 35 seconds, and a cooling time of 1.5 minutes. This parameter combination was able to produce a more stable production process and reduce the number of rejected products compared with the previous condition.

Taguchi Method Analysis

The Taguchi method was used to determine the effects of factors and process parameter levels on the quality of plastic pallets. The quality characteristic used was "smaller the better" because this study aimed to reduce the number of rejected products to the lowest possible level.

Table 7. Results of the Taguchi Method Application

Rejection Type	Predicted Experiment	Confirmation Experiment
Short shot	142 pcs	120 pcs
Uneven coloring	124 pcs	113 pcs
Crack	117 pcs	99 pcs
Total	383 pcs	332 pcs

The total production of plastic pallets during the study was 13,020 pcs, obtained from a production output of 930 pcs per day over 14 working days. Based on the Taguchi experiment results, the predicted number of rejected products was 383 pcs, or:

$$\frac{383}{13.020} \times 100\% = 2{,}94\%$$

After machine parameter optimization was conducted through the confirmation experiment, the number of rejected products decreased to 332 pcs, or:

$$\frac{332}{13.020} \times 100\% = 2{,}55\%$$

These results indicate that process parameter optimization using the Taguchi method successfully reduced the rejection rate by 0.39%.

Optimal Parameter Settings

The following optimal parameter settings were obtained from the confirmation experiment.

Table 8. Optimal Parameter Settings for Short Shot

Factor	Level	Optimum Level Value
Temperature parameter setting (A)	2	200°C
Pressing time (B)	3	50 seconds
Cooling time (C)	1	1 minute

Table 9. Optimal Parameter Settings for Uneven Coloring

Factor	Level	Optimum Level Value

Temperature parameter setting (A)	3	220°C
Pressing time (B)	3	50 seconds
Cooling time (C)	2	1.5 minutes

Table 10. Optimal Parameter Settings for Crack

Factor	Level	Optimum Level Value
Temperature parameter setting (A)	3	220°C
Pressing time (B)	2	35 seconds
Cooling time (C)	3	2.5 minutes

Based on the results of the Taguchi experiment, production machine temperature was found to be the most influential factor affecting the quality of plastic pallets. A machine temperature that was too low caused the material to melt incompletely, resulting in short shot defects. Conversely, an excessively high temperature could cause product discoloration and trigger uneven coloring defects.

In addition to machine temperature, cooling time also had a significant effect on the occurrence of crack defects. A cooling time that was too short caused the product to crack due to unstable temperature changes. Therefore, an optimal combination of parameters is required so that the production process can operate more stably and produce better product quality.

Confirmation Experiment

The final stage was the confirmation experiment, which was conducted to verify the optimal parameter combination obtained from the Taguchi method. The experimental results showed that the optimal parameter combination was able to significantly reduce the product rejection rate, particularly for short shot, uneven coloring, and crack defects.

The application of the optimal parameters also improved the stability of the production process and produced plastic pallets with more consistent quality in accordance with company standards. Therefore, the Taguchi method was proven to be effective as a quality control method for reducing the rejection rate of plastic pallet products on the Sound 1800 machine at PT. Group Cemerlang Plastindo.

CONCLUSION

The conclusions of this study are as follows: Based on the research findings, it can be concluded that the plastic pallet production process on the Sound 1800 machine at PT Group Cemerlang Plastindo still experiences quality problems, as indicated by 2,499 rejected products out of a total production of 107,669 pallets during the period from January 2025 to January 2026. The most dominant types of rejection were short shot, uneven coloring, and crack; therefore, these three types of defects became the main priorities in product quality improvement. The application of the Taguchi method was proven to help determine a more optimal combination of process parameters in reducing the rejection rate. The experimental results showed that the number of rejected products decreased from 383 pcs to 332 pcs, representing a reduction in the rejection ratio of 0.39%. The optimal parameters obtained differed for each type of defect, namely short shot at a temperature of 200°C, a pressing time of 50 seconds, and a cooling time of 1 minute; uneven coloring at a temperature of 220°C, a pressing time of 50 seconds, and a cooling time of 1.5 minutes; and crack at a temperature of 220°C, a pressing time of 35 seconds, and a cooling time of 2.5 minutes. The contribution of this study is to provide a quality control recommendation based on the Taguchi method that can be used by the company to obtain more stable production parameters, reduce waste caused by rejected products, and improve the consistency of plastic pallet quality. The limitation of this study lies in its object focus, which was only conducted on the Sound 1800 machine and the three dominant types of rejection; therefore, the results do not yet represent the entire production process on other machines. Accordingly, future studies are recommended to expand the analysis to broader types of machines, products, and process parameters so that the quality control results become more comprehensive.

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