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Quality Control of Wood Pallet at CV. Mandiri Jaya to Reduce Product Defects Using Statistical Quality Tools and FMEA Methods

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ABSTRACT

This research focuses on improving the quality control of wooden pallets at CV Mandiri Jaya to minimize production defects by utilizing Statistical Quality Tools and the Failure Mode and Effect Analysis (FMEA) method. As a company engaged in manufacturing wooden pallets, CV Mandiri Jaya faces challenges in maintaining consistent product quality. The data collected was analyzed using Statistical Quality Tools, which include check sheets, Pareto diagrams, control charts, and fishbone diagrams to identify and propagate defects. The FMEA method was then applied to determine and prioritize the root causes of defects based on the Risk Priority Number (RPN).The findings show that the most frequent defects are top board dimension mismatch, improper stiffening, and wood cracking. By identifying the root causes of these defects, appropriate corrective actions can be proposed. The results showed that the implementation of this method effectively reduced the number of defective products from 26.1% to 19.5%, which means a decrease of 25.3%. In addition, production efficiency was significantly improved.This research provides a practical framework for manufacturing companies to improve their quality control strategies, ensure higher products, and improve competitiveness in the market.

INTRODUCTION

In an industrial world that continues to grow in various sectors, attention to product and service quality is very important. Companies must make continuous efforts to improve product quality in order to remain competitive and maintain customer loyalty. According to (Indranata et al., 2022), the implementation of quality control in the production process is needed to achieve optimal results while reducing potential losses due to products that do not meet standards.

CV Mandiri Jaya is a company engaged in production, one of which produces wooden pallets. However, this company is faced with various challenges, especially those related to the quality of the wood material used. These challenges result in difficulties in achieving the quality standards set by the company.

Production data shows that CV Mandiri Jaya still experiences a product defect rate that exceeds the predetermined tolerance limit of 10%. This situation indicates that more effective quality control measures are needed. Thus, the company can ensure consistent product quality, increase revenue, and reduce the risk of losing customers due to product dissatisfaction.

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Mandiri Jaya is a company engaged in manufacturing with a main focus on the production of wooden pallets. The company was established on January 10, 2022 as an independent private business entity that produces various types of pallets according to market needs. In an effort to respond to the increasing demand for wooden pallet products, CV Mandiri Jaya began production gradually in mid-2022, with an initial focus on a small scale.

Over time, the company continued to increase its production capacity to meet the needs of an increasingly competitive market. But along the way, CV Mandiri Jaya faces challenges in maintaining product quality, especially in ensuring that each wooden pallet meets the established standards. Therefore, this study aims to analyze and optimize quality control at CV Mandiri Jaya using Statistical Quality Tools and Failure Mode and Effect Analysis (FMEA) methods. With this approach, it is expected to identify the main root causes of product defects and formulate effective improvement strategies to improve production quality and reduce defect rates.

Definition of Quality

The quality of a product or service is the ability to meet the needs and expectations of consumers. In the production process, quality is an important aspect because it has a direct impact on the company's reputation in the market.

(Abdullah et al., 2023) explained that product quality indicates how well a product satisfies customer needs in terms of functionality, superiority, and market value. A high-quality product can be evaluated based on several essential factors, including performance, durability, compliance with standards or specifications, additional features, reliability, aesthetic appeal, perceived value, and ease of maintenance.

Quality Control

(Abdullah et al., 2023) stated that quality control is a technique that must be applied thoroughly, from pre-production to post-production stages, to ensure that the products produced meet predetermined standards. They also added that product quality can be seen from various aspects, such as quantity and product characteristics listed in the quality control specifications. Thus, circuit quality control is a step taken to ensure that the manufactured product conforms to the predetermined quality plan.

Effective quality control will have a positive impact on the products produced. Therefore, careful and continuous supervision during the production process is essential. The procedures carried out must also be in line with the guidelines that have been compiled by the company to maintain product quality consistency. Without continuous quality control, the risk of decreasing the number of customers and losses for the company will be even greater.

Tools Qualitiy Statistik

This research utilizes quality control methods, including Statistical Quality Tools. This approach was initially developed by Kaoru Ishikawa in 1968 and incorporates seven key tools aimed at enhancing quality. These tools consist of check sheets, control charts, fishbone diagrams, histograms, scatter plots, Pareto charts, and stratification.. According to (Sofyan et al., 2024), the use of the Statistical Qualitiy Tools method is very effective in helping the process of identifying and analyzing quality problems in a production system.

FMEA (Failure Mode and Effect Analysis)

Failure Mode and Effect Analysis (FMEA) is an assessment technique that employs a structured, tabular approach to examine the extent of constraints within a system. This method is designed to determine the potential effects of failures occurring during the production process and to identify their root causes.. According to (Aryanto & Auliandri, 2016), FMEA helps in determining potential failures that may occur along the production process and provides corrective measures.

This method allows problems to be sorted based on the Risk Priority Number (RPN) value, which is an indicator of the level of risk. Thus, problem solving priorities can be determined more

systematically. This is in line with research (Basori, 2019), which shows that the use of FMEA is able to provide guidance to solve quality problems in a more focused manner based on the level of urgency.

RESEARCH METHODS

Research conducted at CV Mandiri Jaya uses a quantitative approach with data analysis techniques. The focus of this research is directed at the Quality Control (QC) section to ensure more accurate results. The collected data was analyzed using two methods, namely Statistical Quality Tools and Failure Mode and Effect Analysis (FMEA).

1. Implementation of Statistical Quality Tools
   In the Statistical Quality Tools method, data is analyzed using various tools, including:

   Inspection Sheets: Used to systematically record defect occurrences.

   Pareto Chart: Identify the most dominant types of defects based on their frequency.

   Control Chart (p-Chart): Monitor the stability of the production process and detect variations.

   Fish Bone Diagram: Analyze potential root causes of defects.

After analyzing the data using Statistical Quality Tools, defect trends and their root causes were identified. These results form the basis for applying the Failure Mode and Effect Analysis (FMEA) method.

2. Implementation of Failure Mode and Effects Analysis (FMEA)
   According to (Nisa et al., 2023), the implementation of the FMEA method involves several structured steps:

   a. Identifying Potential Failure Modes
      Identify various possible failures that can occur in equipment or production processes.
   b. Analyzing Causes and Failure Rates
      Examine the underlying cause of each identified failure mode and evaluate its severity (S), likelihood of occurrence (O), and detectability (D).
   c. Calculate the Risk Prioritization Number (RPN)
      Calculate the RPN value by multiplying the severity (S), occurrence (O), and detection (D) scores, which helps prioritize failure mitigation efforts.
   d. Formulate Improvement Strategy
      Based on the RPN values obtained, develop appropriate improvement and maintenance strategies to address the high-priority failure modes.

RESULTS AND DISCUSSION

Check sheet

Check sheets serve as a tool that facilitates the data recording process, usually presented in tabular format to facilitate the management and analysis of information. the use of check sheets to record production data and the number of defects can be seen in Table 1.

Table 1. Wood Pallet production and defect data

Time	Production Quantity	Top Board Size To Length	Improper Recognition	Cracked Wood	Total Defective Products
Day 1	380	35	30	25	90
Day 2	400	38	32	28	98
Day 3	670	55	50	43	148
Day 4	540	50	45	38	133

Time	Production Quantity	Top Board Size To Length	Improper Recognition	Cracked Wood	Total Defective Products
Day 5	410	42	38	30	110
Day 6	480	48	42	35	125
Day 7	350	40	35	28	103
Day 8	510	52	48	40	140
Day 9	470	50	44	38	132
Day 10	386	45	40	35	120
Total	4.596	455	404	340	1.199

Source: CV.Mandiri Jaya

Based on the data presented in the table above, out of a total production of 4,596 pieces, defects were identified in three main categories: Extended Top Board Size with 455 pieces, Improper Stiffening with 404 pieces, and Cracked Wood with 340 pieces. As a result, within a 10-day production period, a total of 1,199 defective pieces were recorded from the overall production.

Pareto Diagram

A Pareto diagram is a tool used to identify and categorize types of defects in products based on their incidence rate. By utilizing this diagram, the most dominant types of defects in production results can be known, so that companies can prioritize corrective steps effectively.

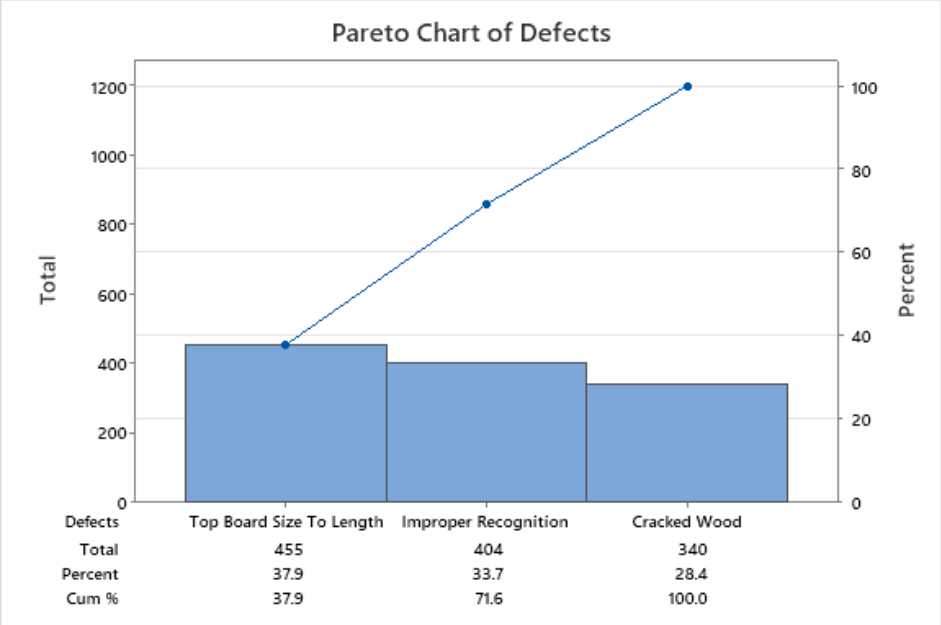

Figure 1. Diagram Pareto

Based on the analysis using a Pareto Diagram, it was found that the most frequent defect in the wood pallet production process at CV. Mandiri Jaya is related to the **Top Board Size to Length**. This type of defect accounts for 37.9% of the total defects, with a recorded frequency of 455 pieces.

Control Chart

In this study, the data analyzed has variations, so the use of a p-chart type control map is considered the most appropriate. This control map is able to conduct a thorough inspection of the production process, as explained by (Sofyan et al., 2024), The results of the control map calculation can be presented as follows:

$$p = \frac{np}{n} = \frac{90}{380} = 0{,}237 \quad (1)$$

Description :

p = Proportion of defects

$n\,p$ = Number of defects

n = Number inspected

$$CL = \bar{p} = \frac{\sum np}{\sum n} = \frac{1.199}{4.596} = 0{,}261 \quad (2)$$

Description :

CL = Center Line

Σnp = Total number of defects

Σn = Total number inspected

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

$$= 0{,}261 + 3\sqrt{0{,}261\frac{(1-0{,}261)}{380}} = 0{,}328$$

Description :

UCL = Upper Control Limit

$\bar{p}$ = Average defective product

n = Production quantity

$$LCL = \bar{p} = -3\sqrt{\frac{\bar{p}\,(1-\bar{p}}{n}} \quad (4)$$

$$= 0{,}261 - 3\sqrt{0{,}254\frac{(1-0{,}261)}{380}} = 0{,}193$$

Description :

LCL = Lower Control Limit

$\bar{p}$ = Average defective product

n = Production quantity

Additionally, calculations for Days 2, 3, and subsequent days on the p-chart, considering varying sample sizes, are conducted to determine the Upper Control Limit (UCL) and Lower Control Limit (LCL). A detailed presentation of these results is provided in Table 2 below.

Table 2. Perhitungan control chart p-chart

Time	Production Quantity	Number of Defective Products	Proportion	CL (center line)	UCL (Upper Control Limit)	LCL (Lower Control Limit)
Day 1	380	90	0.237	0.261	0.328	0.193
Day 2	400	98	0.245	0.261	0.327	0.195
Day 3	670	148	0.221	0.261	0.312	0.210
Day 4	540	133	0.246	0.261	0.318	0.204
Day 5	410	110	0.268	0.261	0.326	0.196
Day 6	480	125	0.260	0.261	0.321	0.201
Day 7	350	103	0.294	0.261	0.331	0.190

Time	Production Quantity	Number of Defective Products	Proportion	CL (center line)	UCL (Upper Control Limit)	LCL (Lower Control Limit)
Day 8	510	140	0.275	0.261	0.319	0.203
Day 9	470	132	0.281	0.261	0.322	0.200
Day 10	386	120	0.311	0.261	0.328	0.194
Total	4.596	1199				

Once the CL (Center Line), LCL (Lower Control Limit), and UCL (Upper Control Limit) values, along with the defect proportion, have been determined, the next step is to develop a p-chart control chart. The generated p-chart can be observed in Figure 2.

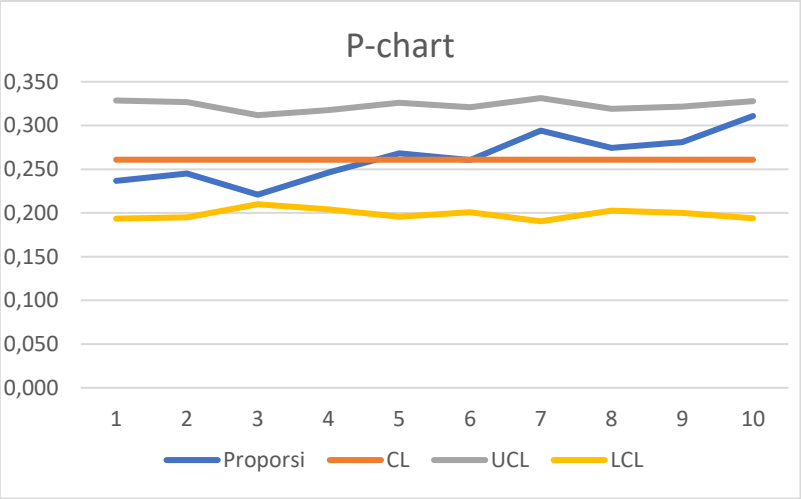

Figure 2. Peta kendali p-chart

Based on the analysis results presented in the figure, all data points fall within the established control limits, including the Upper Control Limit (UCL) and Lower Control Limit (LCL). As a result, no corrective measures are necessary for this process.

Fishbone Diagram

A more in-depth analysis is conducted using a fishbone diagram to determine the root causes and effects that lead to losses in the pallet production process. The findings from this analysis are illustrated in Figure 3-5.

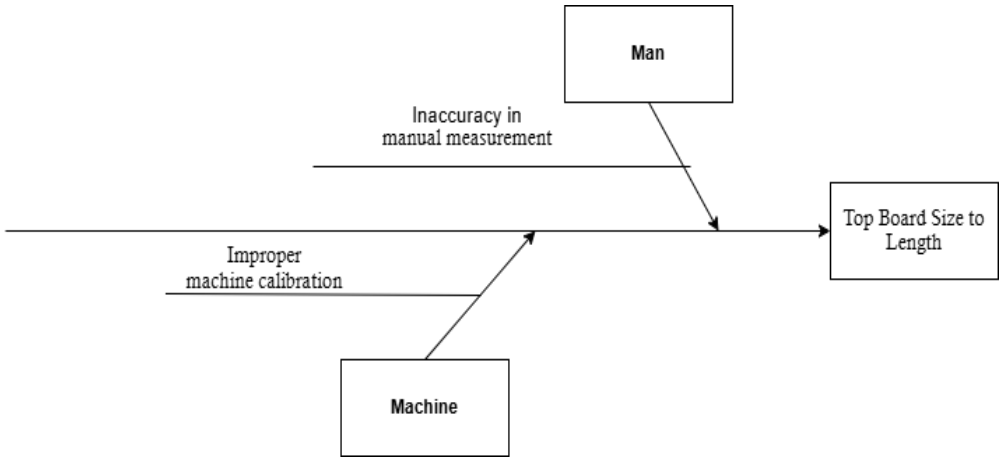

Figure 3. Fishbone diagram of Top Board Size to Length

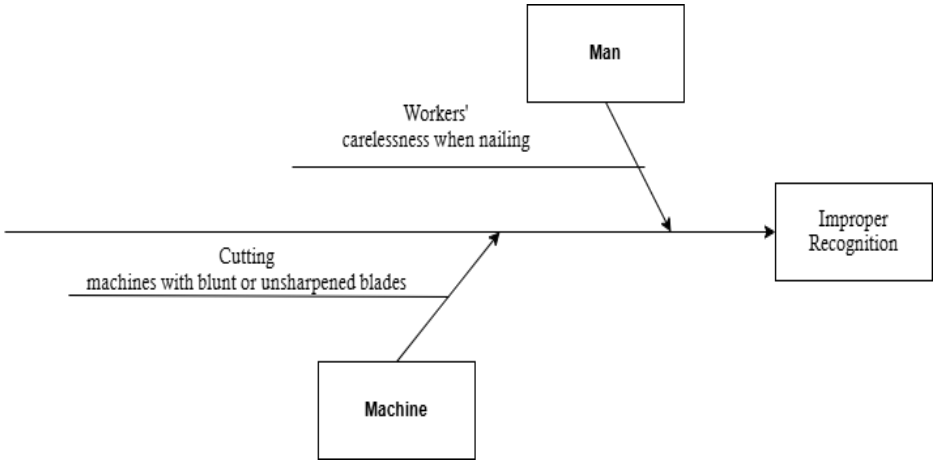

Figure 4. Fishbone diagram of Improper Recognition

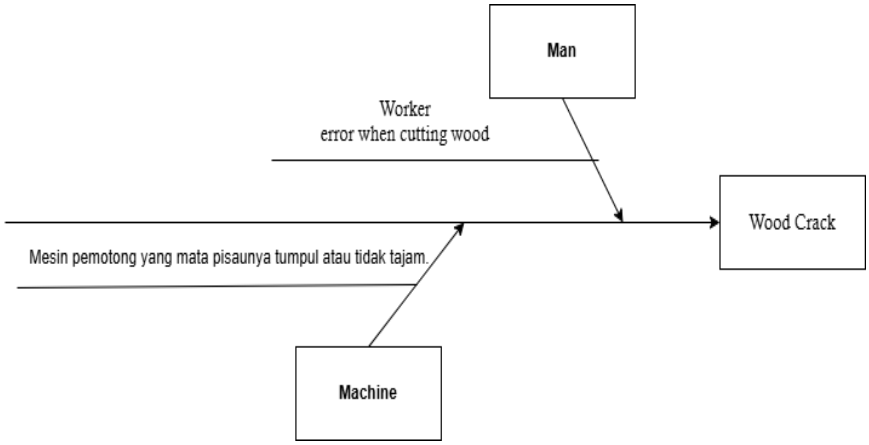

Figure 5. Fishbone diagram of Cracked Wood

Based on the data analysis results using the Fishbone Diagram, several contributing factors leading to defects in the three identified defect types were identified.

FMEA

After processing the data using the tools within the Statistical Quality Tools method, the next step involves conducting a more detailed analysis to establish the priority for addressing issues. This process is performed by applying the Failure Mode and Effect Analysis (FMEA) approach. The analysis results, which include the calculation of the Risk Priority Number (RPN), are presented in Table 4.

According to (Nisa et al., 2023) , FMEA is utilized to assess the risk level of each failure mode by calculating the Risk Priority Number (RPN). The RPN is determined by considering three key factors, namely:

S (Severity) = The level of impact caused by the failure

O (Occurrence) = The likelihood of failure happening

D (Detection) = The capability to identify failures before they cause any consequences

The RPN value is obtained using the following formula:

$RPN = S \times O \times D$

Here is an example calculation :

1. Top Board Size Length

S (Severity) = 6

O (Occurrence) = 6

D (Detection) = 7

RPN = $6 \times 6 \times 7 = 525$

The table below presents respondent information, including their names, positions, departments, and the values for Severity (S), Occurrence (O), Detection (D), and Risk Priority Number (RPN) derived from the report data.

Table 3. Respondents for S, O, D and RPN Values (FMEA - CV. Mandiri Jaya)

Respondents	Failure Type	S	O	D	RPN
1	Long Top Board Size	6	6	7	252
2	Improper machine calibration	6	6	6	216
3	Improper Nailing	7	6	5	210
4	Nailing machine misaligned	5	6	6	180
5	Wood cutting error	5	5	7	175
6	Blunt blade	6	5	5	150

Table 4. RPN value calculation

Failure Type	Causes of failure	S	O	D	RPN
Top Board Size to Length	Inaccuracy in manual measurement	6	6	7	252
	Improper machine calibration	6	6	6	216
Improper Recognition	Workers' carelessness when nailing	7	6	5	210
	Misaligned or unstable nailing machine	5	6	6	180
Wood Crack	Worker error when cutting wood	5	5	7	175
	Cutting machines with blunt or unsharpened blades	6	5	5	150

Referring to Table 4, the Risk Priority Number (RPN) has been determined for each factor contributing to defects. Subsequently, the defect causes are ranked in descending order based on their RPN values. These findings serve as a foundation for formulating improvement strategies aimed at minimizing defects. The proposed improvement plan is presented in Table 4.

Table 5. RPN value calculation

Failure Type	Causes of failure	Proposed Improvement	RPN
Top Board Size to Length	Inaccuracy in manual measurement	Provide additional training to workers to improve accuracy.	252
	Improper machine calibration	Schedule regular machine calibration and meet calibration standards.	216
Improper Recognition	Workers' carelessness when nailing	Provide recognition aids to ensure higher accuracy.	210
	Misaligned or unstable nailing machine	Carry out regular maintenance and checking of the machine to ensure stability..	180
Wood Crack	Worker error when cutting wood	Provide technical training to workers to use cutting tools correctly.	175
	Cutting machines with blunt or unsharpened blades	Replace or sharpen blades regularly to maintain tool sharpness.	150

CONCLUSION

Research conducted at CV Mandiri Jaya shows that the application of Statistical Quality Tools and the Failure Mode and Effect Analysis (FMEA) method is an effective way to identify, analyze, and prioritize the main causes of product defects.

Findings show that the most common defects in the production of wooden pallets include improper top board dimensions, improper stiffeners, and cracked wood. By applying the FMEA method and calculating the Risk Prioritization Number (RPN), the company was able to determine the most critical sources of defects and implement appropriate corrective actions.

As a result, the defect rate was successfully reduced from 26.1% to 19.5%, which means a 25.3% decrease in defective products. This decrease represents a significant improvement in production efficiency and quality consistency. With these improvements, CV Mandiri Jaya can maintain higher product standards, increase customer satisfaction, and strengthen its competitiveness in the industry.

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