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Analysis of Kaizen Implementation with Pareto Approach, Fishbone Diagram & Oee to Reduce Defects in Electronics Industry Assembly Production Line

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ABSTRACT

The high defect rate in the assembly production line of the electronic manufacturing industry is a crucial problem that has an impact on reducing product quality and production efficiency. Based on company data, the defect rate in 2022 reached 12% with the dominant types of defects in the form of solder, bridging, missing components, and cold solder. This study aims to analyze the application of Kaizen as an effort for continuous improvement in reducing defects and increasing productivity. The methods used include Pareto analysis to determine the priority of problems, fishbone diagrams to identify the root cause of defects, and Overall Equipment Effectiveness (OEE) to evaluate the performance of the production system. The research data was obtained in the 2022–2025 period. The results show that the implementation of Kaizen is able to significantly reduce defects to 2% by 2025, increase production output from 400 to 700 units per day, and reduce downtime from 2 hours to 0.5 hours per day, with an OEE value of 71.4% which indicates an increase in production effectiveness. Thus, the application of Kaizen supported by the Pareto method, fishbone diagram, and OEE has proven to be effective in improving product quality and operational efficiency in a sustainable manner.

Keywords: *Kaizen, Defect, Continuous Improvement, Pareto, Fishbone Diagram, OEE, productivity*

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INTRODUCTION

The electronics manufacturing industry is a sector with a high level of competition that demands optimal product quality and production efficiency. In the assembly line, especially products such as PCBs and power supplies, defect problems still occur frequently and are a major source of waste. High defects have an impact on increasing rework and scrap costs, as well as decreased productivity and customer satisfaction (Heizer & Render, 2014).

In modern quality management, quality control must be carried out thoroughly in every production process. W. Edwards Deming emphasizes the concept of built-in quality, so continuous improvement is needed to reduce variation and errors. One of the approaches used is Kaizen, which is the concept of continuous improvement introduced by Masaaki Imai, with a focus on small improvements consistently (Imai, 1986).

The implementation of Kaizen is supported by various quality analysis tools, such as the Pareto method to determine the priority of problems based on the 80/20 principle (Montgomery, 2019), fishbone diagrams to identify root causes based on human, machine, method, material, and environmental factors (Ishikawa, 1985), and Overall Equipment Effectiveness (OEE) to measure production effectiveness from the aspects of availability, performance, and quality (Nakajima, 1988).

Based on actual data from electronics manufacturing companies in Indonesia, the defect rate on assembly lines in 2022 reached 12% of the total production of 10,000 units. Dominant defects include solder bridging, missing component, and cold solder, which mostly occur in the soldering and component installation process. This condition indicates the existence of process inefficiencies that have the potential to increase costs and decrease productivity if not corrected immediately.

Previous research has shown that the application of Kaizen supported by the Pareto method and fishbone diagram is able to significantly reduce defects. Bhuiyan and Baghel (2005) stated that continuous improvement has a positive effect on operational performance, while Singh and Singh (2015) affirmed the effectiveness of Pareto and fishbone in identifying the root of the problem.

Based on this, this study aims to analyze the application of Kaizen in reducing defects in assembly production lines using the Pareto, Fishbone Diagram, and OEE methods. The target of the research is to reduce the defect rate from 12% to a maximum of 5% and increase productivity through the implementation of continuous improvement**.**

RESEARCH METHODS

This study uses a quantitative descriptive approach to analyze the application of Kaizen in reducing defects in the assembly production line of the electronics manufacturing industry. The data used is in the form of secondary data which includes production data, number of defects, downtime, and production output in the 2022–2025 period.

The research stage begins with the identification of the problem, namely the high defect rate of 12%. Next, production and defect data were collected which were analyzed using the Pareto method to determine the type of dominant defect based on frequency

incident so that the priority of repair can be determined.

The next stage is fishbone analysis to identify the root cause of defects based on the 4M + 1E approach, namely humans, machines, methods, materials, and environment. Human factors are related to operator skills, machines with equipment conditions, methods with SOPs, materials with raw material quality, and the environment with work area conditions.

Furthermore, the implementation of Kaizen is carried out through standardization of SOPs, operator training, and the implementation of 5S. The repair results were then evaluated by comparing the conditions before and after the repair, and performance measurements were carried out using Overall Equipment Effectiveness (OEE) to determine the effectiveness of the production system. The following is a flowchart of the flow of the research stages**.**

Figure 1 Research process flowchart

RESULTS AND DISCUSSION

Pareto analysis

Pareto analysis is used to identify the most dominant types of defects so that repair priorities can be determined more effectively. This analysis was carried out based on defect data from 2023 before the implementation of Kaizen.

Table 1 Data Defects in 2023

Type of Defect	Quantity	Percentage (%)	Cumulative (%)
Solder bridging	400	35%	35%
Missing component	300	26%	61%
Cold solder	200	17%	78%

Reverse polarity	150	13%	91%
Scratch / visual	100	9%	100%
Total	**1.150**		

Based on Table 1, the defects with the highest number are bridging solder at 35%, followed by missing components at 26% and cold solder at 17%. These three types of defects contribute a cumulative 78% to the total defects that occur.

To clarify the defect distribution, the data is presented in the form of a Pareto diagram in Figure 2

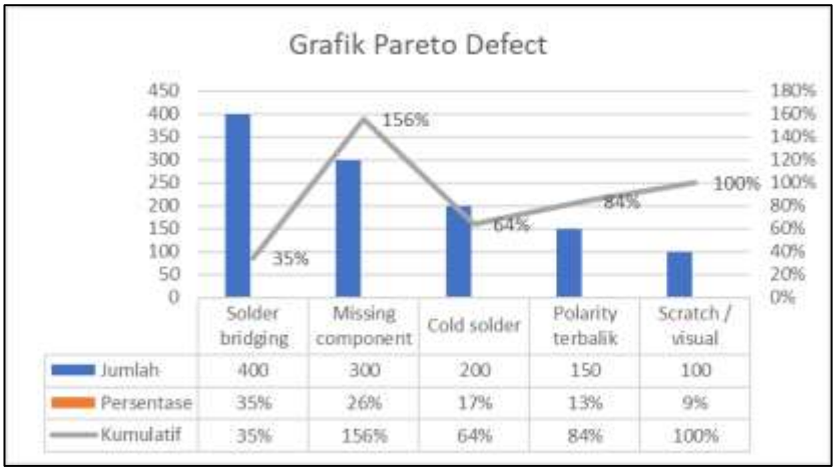

Figure 2 Pareto Defect Chart of 2023

The Pareto graph shows that the defects with the highest frequency are in the bridging solder category, followed by missing components and cold solder. The cumulative line shows a significant increase of up to 78% in the three main types of defects, indicating that most quality problems are concentrated in these categories.

Meanwhile, defects such as reverse polarity and scratch/visual have a smaller contribution to the total defect. Therefore, the priority of repair is focused on defects with the greatest contribution so that repair efforts carried out are more effective and have a significant impact on the overall reduction of defects. Thus, Pareto analysis helps in determining the focus of improvement in a more targeted manner, so that the application of Kaizen can be carried out optimally in improving production quality.

Fishbone Diagram Analysis

Once the priority of the problem is determined through Pareto analysis, the next step is to dig deeper to find the root cause of the high defect rate using the Fishbone Diagram. This analysis was carried out systematically by dividing the causes of the problem into 4M + 1E categories, namely Man (Human), Machine (Machine), Method (Method), Material (Material), and Environment (Environment).

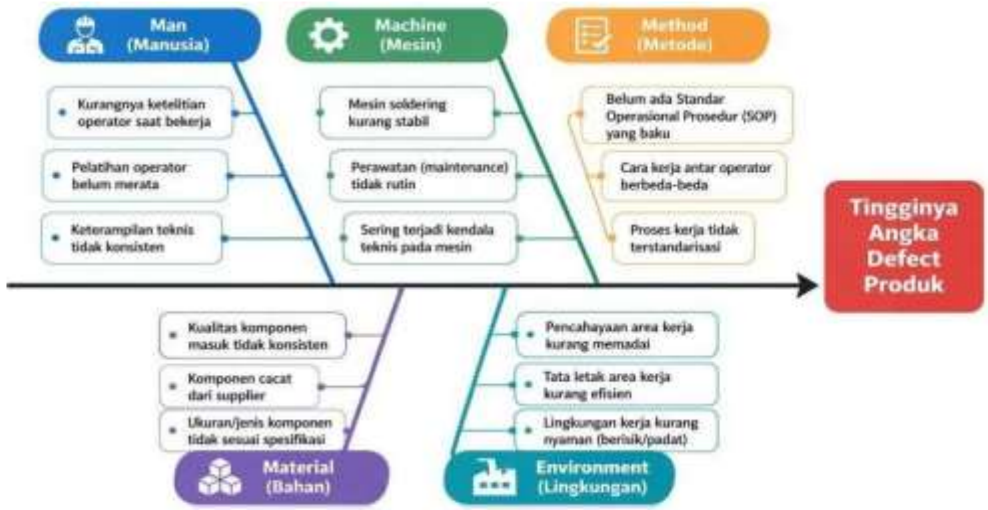

Figure 3 Fishbone Diagram

Based on the results of observations in the assembly line, several main factors that trigger the appearance of product defects are identified:

- Man: The main problem stems from the lack of operator precision at work and the uneven training program for all employees. This results in technical skills in the field being inconsistent.
- Machine: The condition of the soldering machine is often unstable and experiences technical problems due to a maintenance schedule that is not routinely carried out.
- Method: The absence of a standard and clear Standard Operating Procedure (SOP) results in different working methods between operators, so that production results are not uniform.
- Material: It was found that the quality of components entering the production line was sometimes inconsistent, which directly affected the soldering and installation results.
- Environment: Suboptimal working area conditions, such as inadequate lighting or inefficient layouts, also interfere with the operator's focus and comfort on duty.

Kaizen Implementation and Process Improvement

After knowing the root cause of the problem through Pareto analysis and fishbone, the next step is to make real improvements in the field with the concept of Kaizen. These improvements are not carried out all at once, but in stages over two years (2024–2025) so that the changes that occur can be properly monitored.

A. Improvement Stage in 2024

In the first year, the main focus is on fixing the fundamentals that often trigger manual errors. Some of the measures carried out include:

- Component Labeling: Each component container is assigned a clear identity label so that the operator does not mistake the material during the assembly process.
- Layout Changes: Production lines that were originally zig-zag were changed to straight lines.

The goal is to make the flow of goods smoother and the distance of material movement is shorter.

- Machine Calibration: Recalibrate the entire soldering machine to ensure the heat temperature remains stable and up to standard.
- Visual SOPs: Add visual work guides (visual SOPs) at each workstation to make it easier for operators, especially those who are new to follow instructions, without confusing reading long text.

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C. Improvement Stage in 2025

Entering 2025, improvements are being made towards automatic error prevention and tidiness of the work area. The steps include:

- Poka-Yoke Application: Creating an automatic fault prevention system to ensure components are not installed upside down (polarity issues).
- ESD control: Uses equipment such as wrist straps and anti-static mats to protect sensitive electronic components from damage caused by static electricity.
- 5S Culture and Shadow Board: Organize work tools using the shadow board tool. This way, each tool has its own place, so the work area is neater and no time is wasted looking for a key or screwdriver.
- Andon System: Installing indicator lights (Andon) to monitor the production line. If there is a problem, the operator can immediately signal so that the problem is immediately handled by the supervisor.

D. Results of Improvement

This entire series of Kaizen activities has proven to bring great changes to the production line. Human error can be minimized, and the operator's work rhythm becomes faster. The most noticeable thing is the decrease in the number of defects, especially in soldering problems and component positions which were previously the biggest contributors to defects. In addition, this efficiency also has an impact on increasing daily output from only 400 units to 700 units per day.

Production Data and Defect Rate

Based on data on the production lines of the electronics manufacturing industry assembly for the period 2022-2025, an analysis was carried out on the number of productions and defects before and after the implementation of Kaizen.

Table 2 Production and Defect Data for 2022–2025

Year	Conditions	Total Production	Defect (Unit)	Dominant Defect Types
2022	Before Kaizen	10.000	1.200	Solder bridging, missing component
2023	Before Kaizen	11.500	1.150	Cold solder, polarity upside down
2024	Implementation	13.000	650	Less solder sempurna
2025	After Kaizen	14.500	290	Minor visual defect

Based on Table 2, the defect rate in 2022 reached around 12% and only experienced a small decrease to about 10% in 2023. After the implementation of Kaizen in 2024, defects decreased significantly to about 5% and again decreased to about 2% in 2025.

To clarify the trend of decreasing defects that occur from year to year, the data is also presented in the form of a graph in Figure 4.

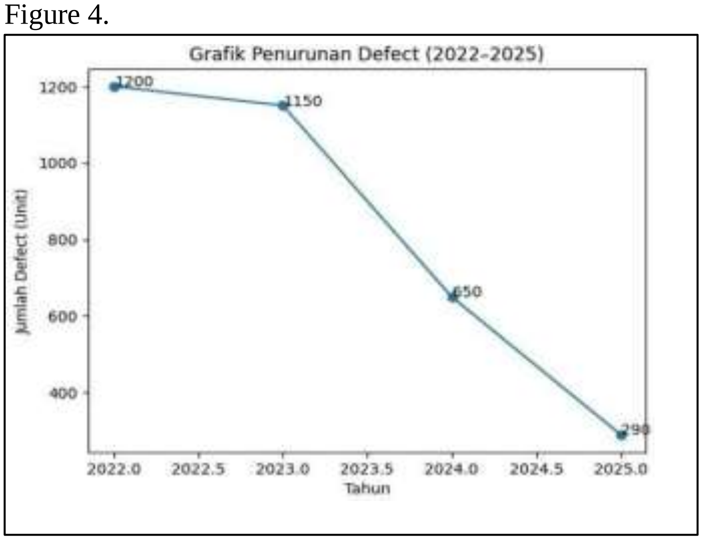

Figure 4 Defect Decline Chart for 2022–2025

This decline shows a consistent improvement in the production process. This trend is also seen in the defect decline chart in figure 4, which shows a more significant decline after the implementation of Kaizen than before.

In addition to the number of defects, there are changes in the type of defect. In the early period, defects were dominated by solder bridging, missing components, and cold solder which were critical.

After repairs, defects that appear in 2025 are only minor visual defects, which shows that the quality of the production process is more stable.

Overall, the application of Kaizen has been proven to be able to gradually reduce defects and improve production quality continuously.

Production Productivity Analysis

In addition to quality, an analysis of production productivity is also carried out to see the impact of the implementation of Kaizen on the efficiency of the work process.

Table 3 Production Productivity Data for 2022–2025

Year	Conditions	Output/Day	Downtime (Hours/Day)
2022	Before Kaizen	400	2,0
2023	Before Kaizen	450	1,8
2024	Implementation	550	1,2
2025	After Kaizen	700	0,5

Based on Table 3, in the period before Kaizen (2022–2023), the increase in output was still limited, from 400 to 450 units per day, with downtime still relatively high. After the implementation of Kaizen in 2024, output increases to 550 units per day and downtime decreases to 1.2 hours.

In 2025, the increase will be even more significant, where output reaches 700 units per day and downtime drops to 0.5 hours. This shows that the production process becomes more efficient and stable after repairs.

To see the efficiency of working time, productivity can also be reviewed based on hourly output.

Table 4 Production Output per Hour

Year	Conditions	Output/Jam
2022	Before Kaizen	50 units
2023	Before Kaizen	56 units
2024	Implementation	69 units
2025	After Kaizen	88 units

The data shows an increase in production speed from 50 units/hour to 88 units/hour. Overall, the implementation of Kaizen not only improves quality, but also has a significant effect on increasing productivity and efficiency of the production process.

Meanwhile, defects such as reverse polarity and scratch/visual have a smaller contribution to the total defect. Therefore, the priority of repair is focused on defects with the greatest contribution so that repair efforts carried out are more effective and have a significant impact on the overall reduction of defects.

Thus, Pareto analysis helps in determining the focus of improvement in a more targeted manner, so that the application of Kaizen can be carried out optimally in improving production quality.

Production Effectiveness Evaluation (OEE)

To measure the success rate of Kaizen implementation, an evaluation of engine performance was carried out using the Overall Equipment Effectiveness (OEE) method in the period of 2025. This evaluation includes the calculation of the level of availability, performance, and quality of the products produced.

Based on the observation results, operational data after the implementation of Kaizen in 2025 was obtained which was used as the basis for the calculation, which is as follows:

- Working time: 8 hours (480 minutes)
- Downtime: 30 minutes
- Actual output: 700 units
- Ideal cycle time: 0.5 minutes/unit
- Number of defects: 290 units out of a total production of 14,500 units (±2%), so that the good product level is 98%.

A. Calculation of OEE Components

Based on the operational data that has been obtained, the calculation of each component of Overall Equipment Effectiveness (OEE) is carried out as follows:

1. Availability

Measure machine readiness by comparing actual operating time against planned production time.

$$Availability = \frac{WaktuOperasi}{WaktuPlanned}$$

$$= \frac{480 - 30}{480} = \frac{450}{480} = 0.9375(93.75$$

2. Performance

Measure the efficiency of the machine in producing products by comparing the actual output to the theoretical output based on the ideal cycle time.

$$Performance = \frac{(Output \times IdealCycleTime)}{WaktuOperasi}$$

$$= \frac{700 \times 0.5}{450} = \frac{350}{450} = 0.778(77.8$$

3. Quality

Quality refers to the ratio of products that meet quality standards (good product) to the total product produced.

$$Quality = \frac{GoodProduct}{TotalOutput}$$

$$= 98$$

4. Overall Equipment Effectiveness (OEE)

$$OEE = Availability \times Performance \times Quality$$

$$= 0.9375 \times 0.778 \times 0.98$$

$$= 0.714(71.4$$

B. Summary of Evaluation Results

The results of the calculation of each component of OEE are then summarized in the following table to facilitate data interpretation.

Table 5 OEE Factor Values in 2025

Factors	**Value (%)**
Availability	93,75
Performance	77,8
Quality	98
OEE Total	**71,4**

For give view Visual About Comparison each of these factors, the OEE achievement is also presented in the form of a bar graph in Figure 5.

Figure 5 OEE Achievement Graph

C. Results Analysis

Based on the calculation results, the OEE value of 71.4% indicates that the production system has been running quite effectively, although there is still room for further improvement.

The Availability value of 93.75% indicates that the level of machine downtime is relatively low, so the availability of machines to support the production process is relatively good. In addition, a Quality value of 98% indicates that most of the products produced have met quality standards, which reflects the success of Kaizen's implementation in reducing product defects.

However, the Performance value of 77.8% is still below the optimal standard, which indicates that the production speed has not fully reached the set ideal capacity. Therefore, improvements in performance aspects need to be the focus of further improvement to increase overall production effectiveness.

Final Discussion

Overall, the results of the study show that the integration of the Pareto method, fishbone diagram, and Overall Equipment Effectiveness (OEE) evaluation in the Kaizen framework is effective in lowering defect rates and improving production efficiency.

The Pareto analysis identified that 78% of quality problems stem from three main types of defects, namely solder bridging, missing component, and cold solder, so that improvements can be focused more appropriately. Furthermore, the fishbone diagram shows that human and machine factors are the dominant causes, so that improvements are focused on SOP standardization, operator training, 5S implementation, and poka-yoke. This effort succeeded in reducing the number of defects from 1,200 units to 290 units.

The OEE value of 71.4% indicates that the production system has been running quite effectively, although it is still below world-class standards (±85%). Thus, continuous improvement efforts are needed, especially in the performance aspect, to increase the overall effectiveness of production.

CONCLUSIONS

Based on the results of the research that has been conducted, it can be concluded that the application of Kaizen in the assembly production line of the electronics manufacturing industry has proven to be effective in reducing the defect rate and increasing the efficiency of the production process. The defect rate was significantly reduced from 12% in 2022 to 2% in 2025.

Pareto analysis shows that most defects are dominated by three main types, namely solder bridging, missing component, and cold solder, with a cumulative contribution of 78%. Furthermore, fishbone analysis identified that human and machine factors were the main causes of defects.

The implementation of Kaizen through SOP standardization, operator training, layout improvement, and the application of the 5S and poka-yoke methods has a real impact on improving quality and productivity. This is shown by the increase in production output from 400 units to 700 units per day and the decrease in downtime from 2 hours to 0.5 hours per day.

In addition, the results of the evaluation using the Overall Equipment Effectiveness (OEE) method showed a value of 71.4%, which indicates that the production system has run quite effectively after repairs. Thus, the application of Kaizen supported by the Pareto method, fishbone diagram, and OEE is able to improve overall production performance.

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