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Quality Control Analysis Using the Seven Tools and Kaizen Methods to Minimize Terminal Defects in the Crimping Process

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ABSTRACT

Product quality control plays a crucial role in maintaining competitiveness in manufacturing industries, particularly in high-volume production processes where minor defects can significantly affect product functionality. This study analyzes quality issues in the crimping process of wiring harness terminals at PT XYZ, where 1,170,016 terminals were produced over an eight-month period, resulting in 1,755 defective units (0.15%). The Seven Tools method including check sheets, histograms, scatter diagrams, control charts, pareto diagrams, fishbone diagrams, and stratification was employed to identify defect types and root causes. The analysis revealed that "too short" defects were the most dominant, accounting for 69.17% of total defects. The p-chart control chart indicated that the defect proportion fluctuated beyond control limits in several periods, signaling process instability. Furthermore, root cause analysis identified five main contributing factors: human, material, method, machine, and environment. Based on these findings, improvement proposals were formulated using the Kaizen approach through the Five-Step Plan and Five-M Checklist, focusing on standardization, training, preventive maintenance, and workplace organization. The proposed improvements are expected to enhance process stability, reduce defect occurrence, and support continuous quality improvement in the crimping process.

Keyword: Quality, Seven Tools, Kaizen, Defects, Terminals

ABSTRAK

Pengendalian kualitas produk memainkan peran krusial dalam menjaga daya saing di industri manufaktur, terutama dalam proses produksi skala besar di mana cacat kecil dapat secara signifikan mempengaruhi fungsi produk. Studi ini menganalisis masalah kualitas dalam proses pengencangan terminal kabel di PT XYZ, di mana 1.170.016 terminal diproduksi selama periode delapan bulan, menghasilkan 1.755 unit cacat (0,15%). Metode Seven Tools termasuk lembar pemeriksaan, histogram, diagram pencar, diagram kendali, diagram pareto, diagram tulang ikan, dan stratifikasi digunakan untuk mengidentifikasi jenis cacat dan penyebab utama. Analisis menunjukkan bahwa cacat "terlalu pendek" merupakan yang paling dominan, menyumbang 69,17% dari total cacat. Diagram kendali p-chart menunjukkan bahwa proporsi cacat berfluktuasi di luar batas kendali pada beberapa periode, menandakan ketidakstabilan proses. Selain itu, analisis penyebab utama mengidentifikasi lima faktor utama yang berkontribusi: manusia, bahan, metode, mesin, dan lingkungan. Berdasarkan temuan ini, usulan perbaikan dirumuskan menggunakan pendekatan Kaizen melalui Rencana Lima Langkah dan Daftar Periksa Lima M, dengan fokus pada standarisasi, pelatihan, pemeliharaan preventif, dan organisasi tempat kerja. Perbaikan yang diusulkan diharapkan dapat meningkatkan stabilitas proses, mengurangi kejadian cacat, dan mendukung perbaikan kualitas berkelanjutan dalam proses crimping.

Keyword: Kualitas, Seven Tools, Kaizen, Kecacatan, Terminal

1. Introduction

In the era of intense industrial competition, manufacturing companies are required to continuously improve product quality in order to meet customer expectations and maintain competitiveness[1]. Product quality not only determines customer satisfaction but also influences production efficiency and cost performance, particularly through reductions in rework, scrap, and warranty claims[2][3]. Therefore, effective quality control systems are essential to ensure that production processes operate consistently within specified standards and requirements.

Quality control refers to a systematic effort to monitor, evaluate, and improve product conformity by identifying deviations from established specifications and implementing corrective actions[4]. In manufacturing environments, ineffective quality control can result in defective products that compromise functional performance and reliability, ultimately affecting organizational productivity and customer trust. As a result, structured and data-driven quality control methods are widely adopted to detect defects early and prevent their recurrence in production processes.

One of the commonly applied approaches in quality control is the Seven Tools method, which consists of check sheets, histograms, scatter diagrams, control charts, Pareto diagrams, fishbone diagrams, and stratification[5]. These tools support the identification of defect patterns, prioritize dominant quality problems, and facilitate root cause analysis based on actual production data. Numerous studies have demonstrated that the Seven Tools method is effective in identifying and analyzing defects across various manufacturing sectors, particularly in processes with high production volumes and repetitive operations[6].

However, the application of the Seven Tools alone is generally limited to problem identification and analysis, and does not inherently provide structured guidance for implementing continuous improvement actions[7]. To address this limitation, the Seven Tools method is often integrated with improvement-oriented approaches such as Kaizen[8][9]. Kaizen emphasizes continuous, incremental improvement involving all organizational levels through structured problem-solving frameworks such as PDCA, Five-Step Plan, and Five-M Checklist[10]. The integration of Seven Tools and Kaizen enables organizations to not only identify quality problems but also design sustainable improvement strategies that address root causes and process variability.

PT XYZ is a manufacturing company specializing in wiring harness production, in which the crimping process plays a critical role in ensuring electrical connectivity and product reliability. During an eight-month observation period, the company recorded 1,755 defective terminals out of 1,170,016 units produced, indicating the presence of quality issues that require systematic investigation. Although previous studies have examined the application of Seven Tools and Kaizen in various manufacturing contexts, research focusing on terminal defects in high-volume crimping processes remains limited. Therefore, this study aims to identify the dominant types and root causes of terminal defects in the crimping process using the Seven Tools method and to propose continuous improvement actions based on the Kaizen approach to reduce defect occurrence and improve process stability[11].

2. Method and Research

This study requires relevant information to sort out and solve the problems being studied. The required sources are divided into two categories:

1. Primary Data. Primary data collected directly from PT XYZ included general company information, production volume data, production defect data, and causes of terminal defects.

2. Secondary Data. Secondary data is obtained from data collected and obtained from outside PT, namely from other sources. Examples include previous reports or literature studies.

The research began with a preliminary study, followed by problem formulation, limitations, and objectives, namely by finding out the background that became the reference for conducting this research due to product defects and the need for quality control[12]. Then, a literature study and field study were conducted, and data was collected by interviewing employees. The data collected included general information about the company, production data, production defect data, and the factors causing the defects. After the data was collected, it was processed using the Seven Tools method, and improvements were proposed using the kaizen method. This method was chosen because it is closely related to quality control and provides suggestions for appropriate solutions to reduce product defects[13]. The following are some of the product defects found during the research:


Figure 1. Bend Up Defect


Figure 2. Too Long Defect


Figure 3. Too Short Defect


Figure 4. Open Barrel Defect

The following is the flowchart for this study:

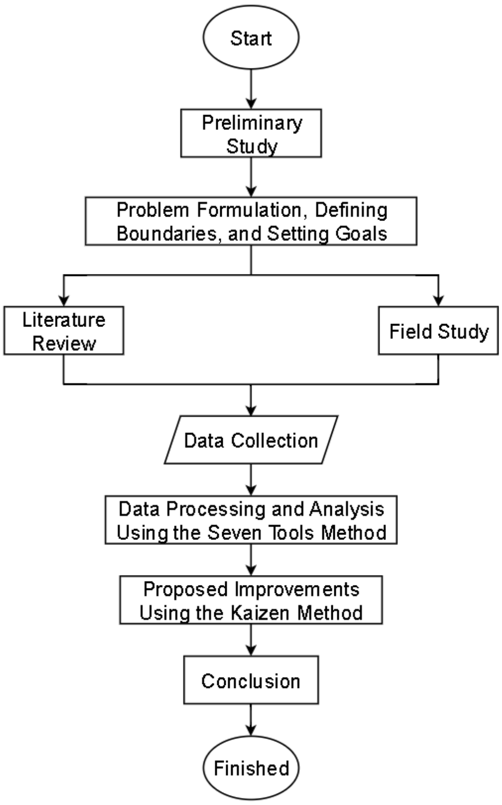

Figure 5. Research Stages

Figure 5 shows the stages of research conducted in this study. The research begins with a preliminary study to identify the general conditions of the production process and initial quality problems. This stage is followed by problem formulation, which includes defining research boundaries and determining research objectives.

Furthermore, a literature review and field study are carried out to obtain theoretical references and actual production data. Data collection is then performed according to the established research scope, followed by data processing and analysis using the Seven Tools method to identify dominant defects and analyze the causes of quality problems. Based on the results of the analysis, improvement proposals are developed using the Kaizen method as a continuous improvement approach. The final stage of the research is drawing conclusions based on the analysis results and proposed improvements.

The following are some of the calculation formulas used in this study:

1. Data sufficiency test (Binomial). The data sufficiency test using the binomial approach is conducted to ensure that the defect data collected are adequate and representative for quality analysis using the Seven Tools. This step is important to confirm that the observed defect patterns truly reflect the actual conditions of the crimping process, thereby providing a valid basis for identifying dominant defects and supporting continuous improvement activities within the Kaizen framework. The formula used in this data adequancy test is:

$$p = \frac{\sum defective\ product}{\sum products\ produced} \quad (1)$$

$$n_{min} = \left[\frac{Z^2.p.(1-p)}{E^2}\right] \quad (2)$$

Explanation: p = overall defect proportion, n_{min} = minimum sample required, Z = 1,96 (95% confidence level), E = Margin of Error (e.g., 0,001 or 0,1% for high precision). If the collected data (total production) exceeds the required minimum sample size (n_{min}). Thus, the data is sufficient for statistical analysis

2. Calculate the upper control limit (UCL) and lower control limit (LCL) using a p-chart type Control Chart. The p-chart type control chart is applied as one of the Seven Tools to monitor the proportion of defective products in the crimping process. The determination of the upper control limit (UCL) and lower control limit (LCL) is used to evaluate process stability and to detect variations that indicate deviations from normal operating conditions. This analysis helps identify quality problems that require corrective actions and serves as a key input for Kaizen-based improvement initiatives. Use the correct p-chart formula, taking into account the sample (ni) each mount:

$$\bar{p} = \frac{\sum proportion\ of\ defects}{n} \quad (3)$$

$$\text{UCL/LCL} = \bar{p} \pm 3\sqrt{\frac{\bar{p}(1-\bar{p})}{ni}} \quad (4)$$

Explanation: $\bar{p}$ = average proportion of defects, n = sample size, ni = monthly sample. If the LCL calculation result is < 0, set LCL = 0 (because defects cannot be negative). UCL and LCL differ each month because the production quantity (n) varies.

3. Calculating ratios. Ratio analysis is used to quantify production quality performance as part of the evaluation stage in the Kaizen improvement cycle. The ratio between the number of good products and total production output reflects the effectiveness of the production process in meeting quality standards, while the ratio between the number of defective products and total production output indicates the level of quality loss. These ratios support decision-making in determining improvement priorities and assessing the impact of Kaizen implementation on defect reduction.

a. Comparison between the number of good products and the number of products producted (ratio 1)

$$\text{Ratio 1} = \frac{good\ product}{products\ produced} \times 100\% \quad (5)$$

b. Camparison between the number of defective products and the number of products producted (ratio 2)

$$\text{Ratio 2} = \frac{defective\ product}{products\ produced} \times 100\% \quad (6)$$

Table 1. Good Ratio and Defective Ratio

Month	Products Produced	Good Product	Defective Product	Good Ratio (%)	Defective Ratio (%)
March	126423	126248	175	99,86%	0,14%
April	106155	106000	155	99,85%	0,15%
May	129814	129428	386	99,70%	0,30%
June	89755	89537	218	99,76%	0,24%
July	165314	164933	381	99,77%	0,23%
August	158097	158047	50	99,97%	0,03%
September	190664	190377	287	99,85%	0,15%
October	203794	203691	103	99,95%	0,05%

Table 1 presents the results of the calculation of the good product ratio and defective product ratio for the crimping process during the observation period from March to October. The table shows the total number of products produced each month, the number of good products, and the number of defective products, followed by the percentage of good and defective ratios. Overall, the results indicate that the production process achieved a high level of quality, with good product ratios consistently above 99% in all observed months. However, variations in the defective product ratio are still observed, indicating fluctuations in process performance. The highest defective ratio occurred in May at 0.30%, followed by June at 0.24% and July at 0.23%, which suggests periods of decreased process stability and increased quality deviation. In contrast, the lowest defective ratio was recorded in August at 0.03%, indicating better process control during that period. These results demonstrate that although the crimping process generally meets quality standards, defect occurrences still vary over time, supporting the need for further analysis using control charts and root cause analysis to identify dominant defects and determine appropriate improvement actions.

3. Result and Discussion

3.1. Seven Tools

1. Check Sheet. Check sheet is one of the Seven Tools used to systematically record and classify defects occurring during the production process. This tool functions as a basic data collection instrument that helps identify the frequency and types of defects in a structured and consistent manner, serving as the foundation for further quality analysis[12].

Table 2. Terminal Defect Check Sheet

Month	Products Produced	Type of Terminal Defect									Number of Defects
		Bend Down	Bend Up	Foreign Object	Slanted	Piled Up	Open Barrel	Scratched	Too Long	Too Short	
March	126423	0	0	0	0	0	100	50	0	25	175
April	106155	0	0	0	0	0	20	0	40	95	155
May	129814	37	40	10	0	8	0	0	0	291	386
June	89755	26	0	0	14	0	0	0	0	178	218
July	165314	26	120	0	0	0	0	0	25	210	381
August	158097	0	0	0	0	0	0	0	0	50	50
September	190664	2	0	0	0	0	0	0	0	285	287
October	203794	0	23	0	0	0	0	0	0	80	103
Total	1170016	91	183	10	14	8	120	50	65	1214	1755

Table 2 presents the results of defect data collection using a check sheet, showing the frequency of each terminal defect type observed during the study period. This table provides an initial overview of defect distribution and serves as the primary data source for further analysis using Pareto diagrams, histograms, and control charts.

2. Scatter Diagram. A scatter diagram is used to identify the relationship or correlation between two variables related to quality performance. In this study, the scatter diagram helps determine whether there is a relationship between potential influencing factors and defect occurrence, which supports deeper analysis of process behavior[14].

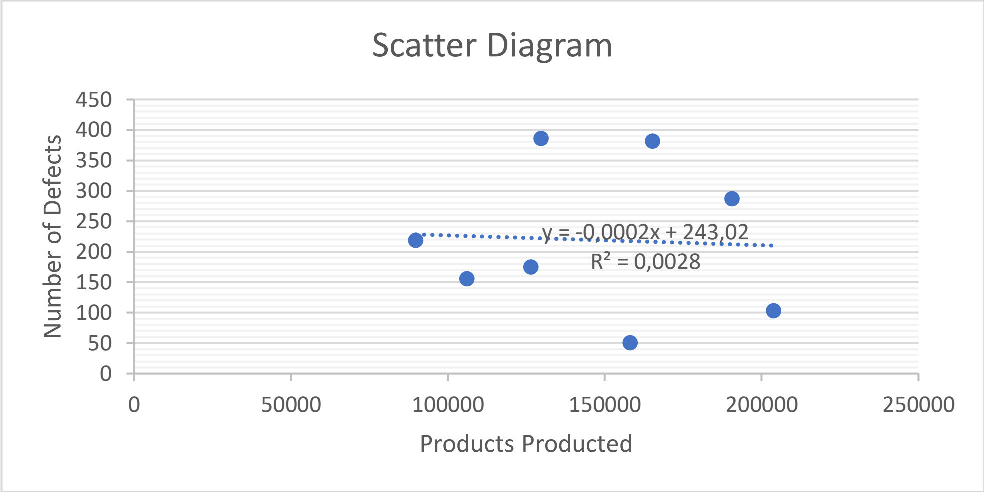

Figure 6. Scatter Diagram

Figure 6 illustrates the scatter diagram used to analyze the relationship between selected process variables and defect occurrence. The pattern shown in the diagram indicates whether a correlation exists, supporting the identification of factors that may influence defect rates in the crimping process.

3. Fishbone Diagram. The fishbone diagram is applied to identify and analyze the root causes of defects by categorizing potential causes into several main factors, commonly referred to as the Five Ms: Man, Machine, Method, Material, and Environment. This tool supports structured root cause analysis and helps determine improvement priorities[15].

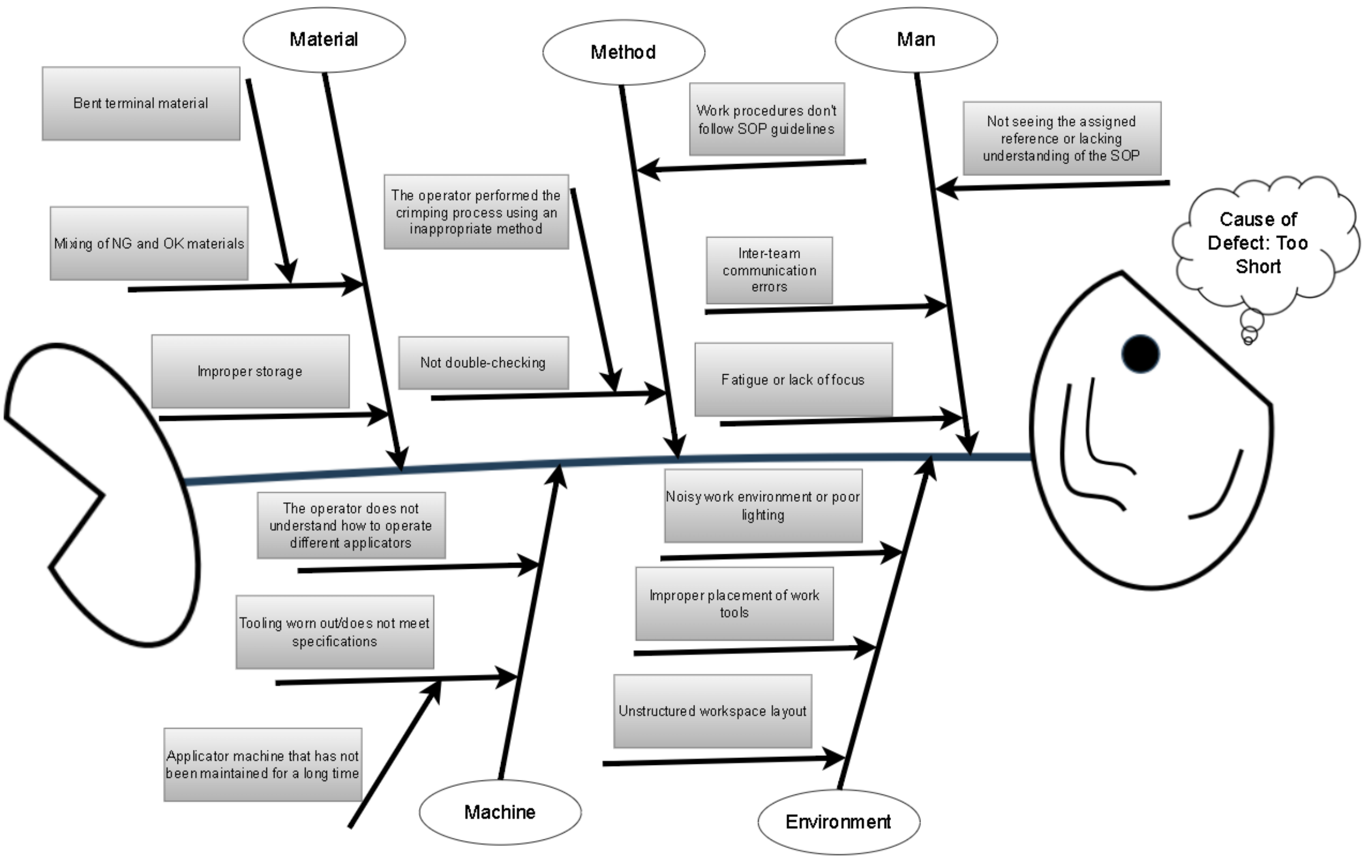

Figure 7. Fishbone Diagram

Figure 7 shows the fishbone diagram that identifies the root causes of terminal defects based on five main factors: human, machine, method, material, and environment. This diagram provides a structured visualization of potential causes and supports the development of targeted improvement actions.

4. Pareto Diagram. The Pareto diagram is used to identify the most significant defect types based on the Pareto principle, which states that a small number of causes often account for the majority of problems. This tool helps prioritize defect types that require immediate corrective action[16].

Table 3. Pareto Chart

Type of Defect	Number of Defects	Percentage	Cumulative Percentage
Too Short	1214	69,17%	69,17%
Bend Up	183	10,43%	79,60%
Open Barrel	120	6,84%	86,44%
Bend Down	91	5,19%	91,62%
Too Long	65	3,70%	95,33%
Scratched	50	2,85%	98,18%
Slanted	14	0,80%	98,97%
Foreign Object	10	0,57%	99,54%
Piled Up	8	0,46%	100,00%
Total	1755	100,00%	

Table 3 presents defect data that have been ranked from the highest to the lowest frequency as preparation for Pareto analysis. This table supports the identification of dominant defects contributing most significantly to quality problems.

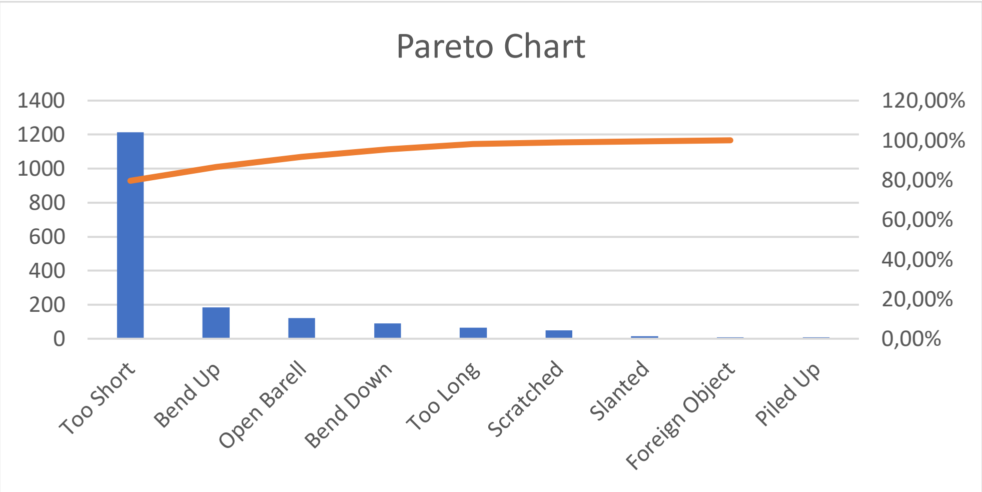

Figure 8. Pareto Chart

Figure 8 displays the Pareto chart of terminal defects, highlighting the most dominant defect type contributing to the majority of quality issues. This visualization confirms defect prioritization and supports focused improvement efforts.

5. Histogram. A histogram is used to illustrate the distribution of defect frequency across different defect categories. This visualization provides insight into defect variation and highlights dominant defect patterns within the production process[17]. Figure 9 shows the histogram of defect types, illustrating the frequency distribution of defects. This histogram helps visualize defect variation and reinforces the identification of dominant defect categories.

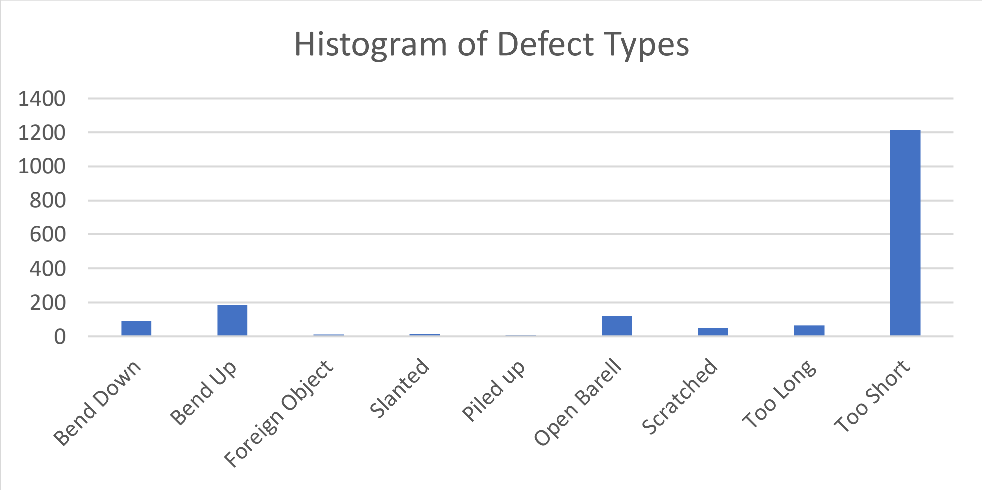

Figure 9. Histogram of Defect Types

6. Control Chart. Control charts are applied to evaluate whether the production process is statistically under control. By comparing process performance against control limits, this tool helps identify abnormal variations that may indicate quality issues[18].

Table 4. Control Chart

Month	Production Quantity	Defects	Defect Proportion	Average	Upper Control Limit (UCL)	Lower Control Limit (LCL)
March	126423	175	0,00138	0,00161	0,00182	0,00118
April	106155	155	0,00146	0,00161	0,00187	0,00113
May	129814	386	0,00297	0,00161	0,00182	0,00118
June	89755	218	0,00243	0,00161	0,00188	0,00112
July	165314	381	0,00230	0,00161	0,00179	0,00121
August	158097	50	0,00032	0,00161	0,00179	0,00121
September	190664	287	0,00151	0,00161	0,00177	0,00123
October	203794	103	0,00051	0,00161	0,00176	0,00124
Total	1170016	1755	0,01288			

Table 4 presents the calculated values required for constructing the control chart, including defect proportions and control limits. This table forms the basis for evaluating process stability.

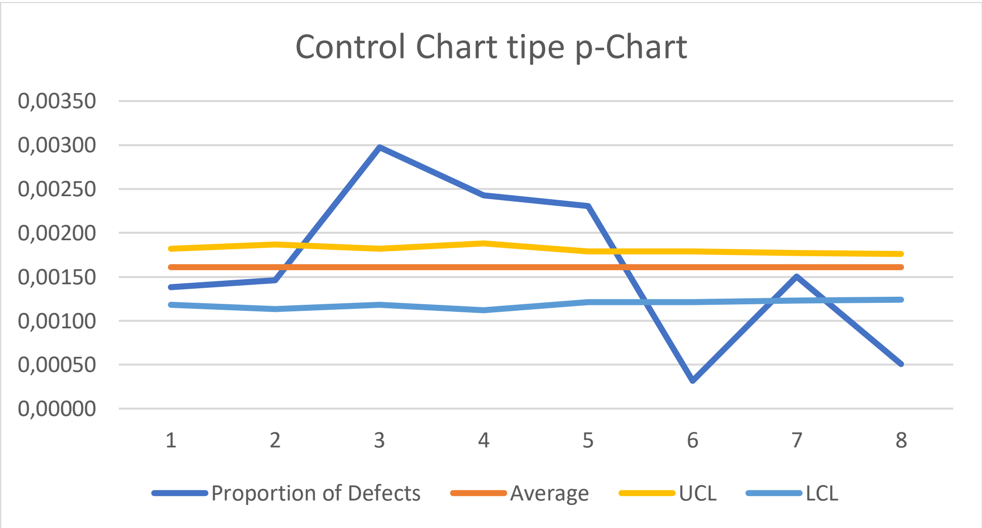

Figure 10. Control Chart tipe p-chart

Figure 10 illustrates the p-chart used to monitor the proportion of defective products over time. The chart shows whether the process operates within control limits and identifies any points indicating abnormal variation.

7. Stratification. Stratification is used to classify defect data into specific categories, such as time period, process stage, or defect type. This tool helps isolate sources of variation and supports more focused analysis[19].

Table 5. Stratification

Defects	Detail Defect	Total	Point Check	Effect
Terminal	Too Short	1214	Remaining core wire length at terminal 0.1 ~ 0.5 mm Std: 0(+0.5, -0.1).	Wire easily comes loose from the terminal.
Terminal	Bend Up	183	Make sure the terminal is perpendicular.	May cause the terminal to break and cannot be installed in the unit.
Terminal	Open Barrel	120	Ensure that the insulation crimp covers the insulation wire.	The terminal cannot be inserted into the connector.
Terminal	Bend Down	91	Make sure the terminal is perpendicular.	May cause the terminal to break and cannot be installed in the unit.
Terminal	Too Long	65	Remaining core wire length at terminal 0.1 ~ 0.5 mm Std: 0(+0.5, -0.1).	Terminal push out/terminal cannot lock onto connector.
Terminal	Scratched	50	Ensure that crimping tools/tooling do not have sharp or dirty parts.	Decreased electrical conductivity and risk of corrosion in scratched areas
Terminal	Slanted	14	Ensure that the terminal is aligned with the wire before crimping.	Uneven connection risk of intermittent connection.
Terminal	Foreign Object	10	Clean the work area of dust or particles before crimping.	Terminal surface damage due to particle friction.
Terminal	Piled Up	8	Set the terminal storage rack capacity according to standards (not exceeding the maximum).	Terminal deformed due to excessive pressure and material retrieval error (swapped).

Table 5 presents stratified defect data based on specific classification criteria. This table helps identify patterns or trends related to defect occurrence and supports more focused improvement analysis.

3.2. Kaizen

After identifying defects that occur in the crimping process using the Seven Tools method to determine the cause of the defects, further analysis is then carried out in an effort to reduce the number of product defects. This analysis uses the Kaizen Five-Step Plan& Five-M Checklist method.

The Kaizen Five-Step Plan is a structured continuous improvement approach consisting of problem identification, analysis, planning, implementation, and evaluation. This method ensures systematic and sustainable quality improvement based on data-driven analysis.

Table 6 presents the Kaizen Five-Step Plan applied in this study, outlining the systematic steps taken from problem identification to evaluation. This table demonstrates how continuous improvement initiatives are structured and implemented.

The Kaizen Five-M Checklist is used to evaluate improvement actions across the five main contributing factors (Man, Machine, Method, Material, and Environment). This checklist ensures that corrective actions comprehensively address all potential sources of defects.

Table 6. Kaizen Five-Step Plan

Five Step Plan	Implementation Recommendations
Seiri (Sort)	Remove unnecessary tools/materials from the work area to avoid using the wrong components/tools.
	Categorization of materials to ensure that only quality materials are processed
Seiton (Set in Order)	Arrange tools/materials with labels and fixed locations to prevent errors in retrieval.
	Separate materials that have been crimped to prevent accumulation.
Seiso (Shine)	Schedule regular cleaning of machinery/work areas to prevent contamination.
	Visual inspection during cleaning to detect tool damage/process abnormalities
Seiketsu (Standardize)	Follow SOP guidelines to ensure process consistency
	Implementation of color/warning signs to prevent human error
Shitsuke (Sustain)	Train employees regularly on 5S procedures and the importance of discipline.
	Conducting a briefing before production activities

Table 7 shows the Kaizen Five-M Checklist used to evaluate improvement actions across human, machine, method, material, and environmental factors. This checklist ensures that corrective actions comprehensively address all identified root causes.

Table 7. Kaizen Five-M Checklist

Factors	Causes	Proposed Improvements
Man	Not seeing the intended reference or lacking understanding of the SOP	Implementation of the double-check culture
	Fatigue or lack of focus	Implementation of job rotation or structured breaks
	Communication errors between teams	Use visual management (instruction boards) and daily briefings
Material	Bent terminal material	Implementation of 100% inspection of incoming materials
	Improper storage	Warehouse standardization (Seiri, Seiton) and temperature/humidity control
	Mixing of NG and OK materials	Color label
Method	Work procedures do not follow SOP guidelines	Consistently follow SOP instructions
	The operator performed the crimping process using an inappropriate method.	Operators consistently perform existing methods
	Not double-checking	Performing a recheck after completing the process
Machine	Applicator machine that has not been maintained for a long time	Schedule preventive maintenance and machine condition monitoring
	Tooling worn out/does not meet specifications	Implementation of total productive maintenance (TPM) and spare parts management
	The operator does not understand how to operate different applicators.	Operators must understand the settings of each applicator before performing the process.
Environment	A noisy work environment or poor lighting	Install ergonomic lighting and sound insulation
	Improper placement of work tools	Use a shadow board with tool outlines and color labels
	Unstructured workspace layout	Apply (Seiri, Seiton) for organization and safety marking

Based on the results of the Seven Tools analysis, the most dominant defect at PT XYZ was the too short terminal defect, with 1,214 cases or 69.17% of the total defects, making it the main priority for quality control improvement. Analysis using a fishbone diagram identified five contributing factors: human, material, method, machine, and environment. Human factors include operators not fully understanding or referring to SOPs, fatigue or lack of focus, and miscommunication between teams. Material-related causes involve bent terminals, improper storage, and the mixing of NG and OK materials. Method factors arise from work procedures that do not comply with SOPs, inappropriate crimping techniques, and the absence of rechecking. Machine factors are related to applicator machines that lack regular maintenance, worn or non-standard tooling, and limited operator knowledge in handling different applicators. Environmental factors include noisy or poorly lit work areas, improper tool placement, and unstructured work layouts. Based on the Kaizen analysis, improvement efforts are proposed through root cause analysis using the 5 Whys method, the formation of a PDCA team focused on reducing too short defects, implementation and strengthening of the 5S culture, routine briefings to reinforce the quality promise mindset, and application of the "Stop–Call–Wait & Do" principle when abnormalities occur[20][21]. The implementation of these improvements is expected to reduce the defect rate below the tolerance limit of 5%, increase productivity, reduce repair costs, and maintain customer trust. Future research may integrate Failure Mode and Effects Analysis (FMEA), apply the Six Sigma DMAIC approach, and incorporate ergonomic and human factors studies to support continuous quality improvement.

4. Conclusion

This study demonstrates that the application of the Seven Tools method effectively identified quality problems in the crimping process at PT XYZ, with "too short" defects emerging as the dominant issue, accounting for 69.17% of total defects from an overall defect rate of 0.15%. Root cause analysis using a fishbone diagram revealed that defects were influenced by five main factors: human, material, method, machine, and environment. The instability observed in the p-chart control chart further confirmed the need for systematic process improvement. Based on these findings, the Kaizen approach was employed to develop continuous improvement proposals through the Five-Step Plan and Five-M Checklist, emphasizing standard operating procedures, operator training, preventive maintenance, and workplace organization. The implementation of these improvement strategies is expected to reduce defect occurrence, improve process consistency, and support sustainable quality performance in the crimping process.

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