Jurnal Multidisiplin Indonesia (JOUMI)
Volume 4 Nomor 2 Juni 2026
E-ISSN .: 2986-7541; P-ISSN .: 2986-7533, Hal 536-554
DOI: https://doi.org/10.62007/joumi.v4i2.793
Tersedia : https://ejournal.alhafiindonesia.co.id/index.php/JOUMI

Six Sigma Based Quality Control Analysis for Wiring Harness Production at PT Tae Bong Indonesia

Arga Febri Saputra[1*], Siti Rahayu[2], dan Andini Putri Riandani[3]
[1-3]Industrial Engineering Study Program, Faculty of Engineering, Universitas Pelita Bangsa, Indonesia
Email: argafebrisaputra2@gmail.com[1], siti.rahayu@pelitabangsa.ac.id[2], andiniriandani@pelitabangsa.ac.id[3]
**Corresponding Author:* argafebrisaputra2@gmail.com

Abstract. This study examines the quality performance of wiring harness production at PT Tae Bong Indonesia using the Six Sigma approach with the DMAIC methodology. The production process experiences a quality issue characterized by a defect rate of 6.15%, which exceeds the company's maximum tolerance limit of 5%. The objective of this study is to evaluate process capability, identify dominant defect types, analyze root causes, and propose structured improvement strategies to reduce defects in the production process. This research uses a quantitative descriptive case study design based on production and defect data collected from January to June 2025. The analytical methods include Defects per Unit (DPU), Defects per Opportunity (DPO), Defects per Million Opportunities (DPMO), sigma level calculation, Pareto analysis, p-chart, fishbone diagram, and 5 Whys analysis. The results show an average DPMO value of 20,500 with a sigma level of 3.55, indicating that the process capability is at a moderate performance level. The dominant defects identified are burned wire, imperfect crimping, and retainer no locking, which contribute 78.64% of total defects. The root causes are mainly related to unstable machine parameters, inconsistent maintenance practices, non-standardized work methods, and weak inspection control. Proposed improvements focus on process parameter standardization, preventive maintenance enhancement, inspection system strengthening, and implementation of structured control plans. This study provides a practical reference for improving process stability and reducing defects in wiring harness manufacturing.

Keywords: Defect; DMAIC; DPMO; Quality Control; Six Sigma; Wiring Harness.

1. INTRODUCTION

The manufacturing industry plays an important role in supporting national economic growth and industrial competitiveness. In Indonesia, the manufacturing sector contributed around 17.39% to the national Gross Domestic Product in 2025 Pusat & Tistik (2025), this condition shows that manufacturing companies must maintain production performance through stable processes and consistent product quality. Product quality has become a critical factor because it affects customer satisfaction, production efficiency, and business sustainability. Azis & Vikaliana (2023) stated that good quality reflects the company's ability to control its production process so that products meet predetermined specifications.

Quality problems in manufacturing often occur due to unstable processes and inconsistent production control. A process that is not properly controlled can increase defects, rework, material waste, and production delays. Mabrur (2021), explained that a higher defect rate in a production process leads to greater waste of resources, including cost, time, and labor Apri et al. (2025) also stated that quality problems in manufacturing can occur due to process inconsistency, which causes defective products. Therefore, quality control is needed to maintain process stability and reduce nonconforming products.

Naskah Masuk: 24 April 2026; Revisi: 25 Mei 2026; Diterima: 29 Juni 2026; Terbit: 30 Juni 2026

PT Tae Bong Indonesia is a manufacturing company that produces electronic components, especially wiring harness products. A wiring harness is an important component in electrical and electronic systems because it connects and distributes electrical signals between components. Based on field observation, the wiring harness production process still experienced several defects, such as burned wire, imperfect crimping, and retainer no locking. These defects indicate problems related to machine conditions, work methods, process parameters, and inspection activities.

To strengthen the problem statement, production and defect data from January to June 2025 were used as the initial basis for identifying the quality problem. The company has set a maximum defect tolerance of 5%. However, the actual defect percentage during the observation period exceeded this standard, as shown in Table 1.

Table 1. Production and Defect Data of Wiring Harness from January to June 2025.

Month	Total Production (Unit)	Total Defect (Unit)	Defect Percentage (%)
January	10,250	650	6.34
February	7,300	440	6.03
March	9,500	580	6.11
April	8,200	510	6.22
May	9,350	560	5.99
June	10,200	630	6.18
Total / Average	54,800	3,370	6.15

Source: Production data of PT Tae Bong Indonesia, 2025.

Based on Table 1, the average defect percentage reached 6.15%, which exceeded the company tolerance limit of 5%. This result shows that the wiring harness production process had not achieved the expected quality target. The highest defect percentage occurred in January at 6.34%, while the lowest occurred in May at 5.99%. Although the defect percentage fluctuated, all monthly values remained above the company tolerance limit. This condition indicates that the quality problem occurred repeatedly and required a structured improvement approach.

Six Sigma is a data-based quality improvement method that can be used to measure process performance, identify dominant defects, analyze root causes, and develop improvement actions. (Fedyawan, 2023) stated that Six Sigma can reduce defect levels through process capability improvement using the DMAIC approach. (Rosyid Firmansyah, Nida An Kofiyah, 2025) also explained that Six Sigma DMAIC can be used as a quality control method to reduce product defects in manufacturing processes. In addition, (Zulkhulaifah & Apriliani, 2024) showed that Six Sigma can evaluate process performance through Defects Per Million Opportunities (DPMO) and sigma level.

Previous studies have demonstrated the effectiveness of Six Sigma DMAIC in reducing defects across various manufacturing sectors; however, most studies have focused on general production processes such as food, plastic, automotive components, and other manufacturing industries. Wiring harness production has unique characteristics because it involves a combination of automated equipment, manual assembly activities, and critical connection processes such as soldering, crimping, and locking mechanisms, where small process variations can directly affect product functionality. Therefore, this study contributes by applying an integrated Six Sigma DMAIC framework specifically to a wiring harness assembly process, combining defect prioritization, statistical process capability measurement, root cause identification, and structured improvement planning. Unlike previous studies that mainly focus on defect reduction measurement, this research provides a practical improvement framework based on actual production conditions to strengthen quality control in electronic component manufacturing.

This study aims to analyze the quality performance of the wiring harness production process, identify dominant defect types and their root causes, and propose improvement actions to reduce defects. The scope of this study is limited to production and defect data from January to June 2025, with a focus on three dominant defects: burned wire, imperfect crimping, and retainer no locking. The results of this study are expected to support continuous quality improvement and help the company strengthen process control in wiring harness production.

2. LITERATURE REVIEW

Quality Control

Quality control is a systematic activity used to ensure that products meet predetermined standards and specifications. It focuses on monitoring production processes, identifying defects, and implementing corrective actions to reduce nonconforming products. Effective quality control helps companies improve efficiency, reduce waste, and increase customer satisfaction. According to Firmansyah & Kofiyah (2025), quality reflects the company's ability to control production processes so that output meets established requirements. In manufacturing environments, quality control is essential to maintain process stability and prevent repeated defects.

Six Sigma

Six Sigma is a data-driven methodology used to improve process quality by reducing variation and defects. Recent studies have shown that Six Sigma remains widely applied in manufacturing industries due to its ability to combine statistical analysis and structured improvement approaches. Six Sigma implementation through the DMAIC framework enables organizations to identify process variation, determine root causes, and develop measurable improvement strategies. The effectiveness of Six Sigma is strongly influenced by the systematic use of data analysis and continuous monitoring to ensure sustainable quality improvement (Yu et al., 2022). The main objective of Six Sigma is to achieve near-perfect quality performance with minimal defect rates. This method uses statistical indicators such as Defects per Unit (DPU), Defects per Opportunity (DPO), Defects per Million Opportunities (DPMO), and sigma level to evaluate process capability. Mochammad Basjir & Suhartini (2023) stated that Six Sigma can reduce defect levels through systematic process improvement. In addition, (Mahira, Prasteyo Hadi, 2021) explained that Six Sigma is effective in evaluating process performance using DPMO and sigma level as key performance indicators in manufacturing systems.

DMAIC Method

DMAIC is a structured problem-solving framework within Six Sigma consisting of Define, Measure, Analyze, Improve, and Control. The Define phase identifies the main problem and Critical to Quality (CTQ) characteristics. The Measure phase evaluates current process performance using statistical tools. The Analyze phase identifies root causes of defects. The Improve phase develops corrective actions, and the Control phase ensures that improvements are sustained. Firmansyah & Kofiyah (2025) explained that the DMAIC approach provides a structured method for reducing product defects in manufacturing processes. This framework is widely used because it ensures improvement actions are data-based and continuously monitored.

Previous Studies

Previous research shows that Six Sigma is effective in reducing defects in various manufacturing industries. Studies have demonstrated that the DMAIC approach can significantly improve process capability and reduce production errors. However, most previous studies focus on general manufacturing processes, while limited research specifically addresses wiring harness production in electronic component industries. This gap indicates the need for further research that integrates Six Sigma analysis with specific defect types in wiring harness production, such as burned wire, imperfect crimping, and retainer no locking. International studies have also confirmed the effectiveness of DMAIC in defect reduction. (Imansuri et al., 2024) applied DMAIC methodology in an automotive manufacturing process and showed that systematic defect analysis can support improvement decisions. Similarly, (Condé et al., 2022) demonstrated that Lean Six Sigma and DMAIC approaches can reduce manufacturing defects through identification of critical process factors.

3. RESEARCH METHODS

Research Design

This study used a descriptive quantitative approach with a case study method. The quantitative approach was used because the quality performance of the production process was measured using numerical data, such as total production, total defects, defect percentage, Defects Per Million Opportunities (DPMO), and sigma level. The descriptive approach was used to explain the actual condition of the wiring harness production process and to identify the causes of product defects based on field data. The case study was conducted at PT Tae Bong Indonesia because the company experienced quality problems in wiring harness production and required structured improvement proposals.

This study applied the Six Sigma method with the DMAIC approach, which consists of Define, Measure, Analyze, Improve, and Control. This approach was selected because it provides systematic stages to identify quality problems, measure process performance, analyze root causes, propose improvement actions, and design process control. Mahira & Hadi (2021) stated that Six Sigma can reduce defect levels through process capability improvement using the DMAIC approach. Al-faritsy et al. (2022) also explained that DMAIC provides a structured and measurable cycle for solving quality problems.

Research Object and Scope

The research object was the wiring harness production process at PT Tae Bong Indonesia. The analysis focused on production and quality inspection data from January to June 2025. The defect types analyzed in this study were burned wire, imperfect crimping, and retainer no locking. These defects were selected because they directly affected product conformity and increased rework activities. Damayant et al. (2022) stated that quality control must become part of the quality management system and should be implemented through planned activities in each production line. Nanlohy (2024) also explained that quality control involves material selection, machine condition monitoring, operator work procedures, and final product inspection. Therefore, this study focused on the assembly process because this stage had direct interaction with operators, machines, working methods, and inspection activities. The defect classification was determined based on the company’s quality inspection standards and the frequency of defect occurrence during the observation period. Three dominant defect categories were selected as Critical to Quality (CTQ), namely burned wire, imperfect crimping, and retainer no locking. These defects were selected because they directly affected product functionality, required rework activities, and represented the highest contribution to total defects based on Pareto analysis.

Data Collection

The data collection procedure was conducted through three stages. First, direct observation was performed in the wiring harness production area to understand the production flow, identify critical production activities, and observe potential defect sources during soldering, crimping, and assembly processes. Second, interviews were conducted with production supervisors, operators, and Quality Control personnel to validate defect characteristics, production constraints, inspection procedures, and possible causes of quality problems. Third, historical production records and quality inspection documents were collected from the company database, including monthly production quantity, defect quantity, and defect classification records. Secondary data were obtained from company documentation, including monthly production reports, defect records, and quality inspection data from January to June 2025. Mochammad Basjir & Suhartini (2023) stated that quality control should be applied from the pre-production stage, during production, until the final product is produced. Khalisan & Hasibuan (2025) also emphasized that quality improvement must be carried out continuously through equipment maintenance and periodic product inspection. Therefore, observation, interviews, and documentation were used together to obtain complete information about the actual quality condition. The sampling method used in this study was total sampling. All production and defect data recorded during January to June 2025 were included in the analysis. The use of total sampling was selected because the research utilized historical production data from the Quality Control department, where all available defect records during the observation period represented the actual quality performance of the production process. Therefore, no data exclusion was applied.

Research Flow

The research procedure was arranged systematically to ensure that each stage of analysis was connected to the research objectives. The research flow followed the DMAIC framework because this framework provides structured stages for defining problems, measuring process performance, analyzing root causes, proposing improvements, and controlling the process. Widyaningrum & Al-faritsy (2026) explained that DMAIC supports quality improvement through defect reduction and process performance improvement. Al-

Faritsy (2022) stated that DMAIC ensures each improvement step is measurable and sustainable. The research flow is shown in Figure 1.

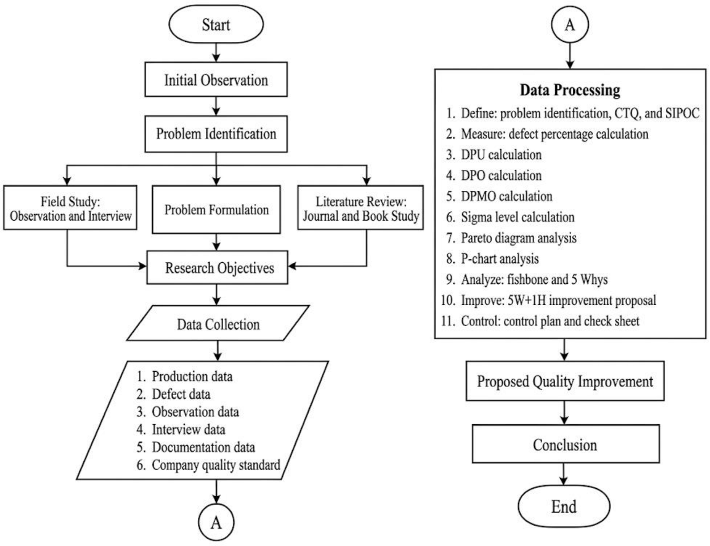

Figure 1. Research flowchart.

Figure 1 shows that the study began with initial observation and problem identification in the wiring harness production process. The problem identification stage was supported by field study, problem formulation, and literature review. After the research objectives were determined, data were collected from production data, defect data, observation data, interview data, documentation data, and company quality standards. The collected data were then processed using the DMAIC stages to produce proposed quality improvements.

Data Processing and Analysis

Data processing and analysis were conducted using the Six Sigma DMAIC stages. This method was used because it combines statistical measurement, root cause analysis, and structured improvement planning. Fradinata et al. (2022) explained that Six Sigma can measure process performance through DPMO and sigma level. Suprapto et al. (2023) stated that Six Sigma uses statistical methods to evaluate and improve process performance. The data processing stages in this study consisted of Define, Measure, Analyze, Improve, and Control.

Define Stage

The Define stage was used to identify the main quality problem in the wiring harness production process. The problem was determined by comparing the actual defect percentage with the company tolerance limit of 5%. Critical to Quality (CTQ) characteristics were determined based on the dominant defect types, namely burned wire, imperfect crimping, and retainer no locking. SIPOC was also used to describe the relationship between supplier, input, process, output, and customer in the production process. Putri et al. (2023) stated that the

Define stage aims to identify quality problems and determine important quality characteristics. In this study, CTQ was used to define defect opportunities that directly affected product conformity.

Measure Stage

The Measure stage was used to evaluate the actual quality performance of the wiring harness production process. The analysis included defect percentage, DPU, DPO, DPMO, sigma level, Pareto diagram, and p-chart. Suhendra (2025) stated that DPMO and sigma level can be used to evaluate process capability in Six Sigma. Akbar (2024) also explained that statistical measurement in Six Sigma helps companies evaluate actual process performance. The defect percentage was calculated using Equation (1).

$$Defect\ Percentage = \left(\frac{Total\ Defect}{Total\ Production}\right) \times 100\% \quad \text{(i)}$$

DPU was calculated to determine the average number of defects per production unit, as shown in Equation (2).

$$DPU = \frac{Total\ Defect}{Total\ Production} \quad \text{(ii)}$$

DPO was calculated to measure the probability of defects based on the number of defect opportunities in each unit, as shown in Equation (3).

$$DPO = \frac{Total\ Defect}{Total\ Production \times CTQ} \quad \text{(iii)}$$

DPMO was calculated to measure the number of defects per one million opportunities, as shown in Equation (4).

$$DPMO = DPO \times 1.000.000 \quad \text{(iv)}$$

The sigma level was calculated by converting the DPMO value into the standard normal distribution and adding the 1.5 sigma shift, as shown in Equation (5).

$$Sigma\ Level = Z\left(1 - \frac{DPMO}{1.000.000}\right) + 1.5 \quad \text{(v)}$$

Where Z is the inverse standard normal distribution value.

The p-chart was used to determine whether the defect proportion was statistically controlled. The center line, upper control limit, and lower control limit were calculated using Equations (6), (7), and (8).

$$CL = \bar{p} \quad \text{(vi)}$$

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

$$\mathrm{LCL} = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \quad \text{(viii)}$$

Where $\bar{p}$ is the average defect proportion and n is the total production in each observation period. If the LCL value was negative, the value was set to zero because defect proportion cannot be less than zero.

Analyse Stage

The Analyse stage was used to identify the root causes of dominant defects. The analysis was conducted using a fishbone diagram and 5 Whys analysis. The fishbone diagram classified possible causes into five categories: man, machine, method, material, and environment. The 5 Whys analysis was then used to trace deeper root causes of burned wire, imperfect crimping, and retainer no locking. Al-Faritsy (2022) explained that the Analyse stage in DMAIC is used to identify root causes of quality problems and process variation. In this study, this stage helped determine whether the defects were caused by machine instability, nonstandard methods, operator factors, material conditions, or workplace environment.

Improve Stage

The Improve stage was used to develop improvement proposals based on the root causes identified in the Analyse stage. The improvement proposals were prepared using the 5W+1H method, which consists of what, why, where, when, who, and how. Al-Faritsy (2022) stated that the Improve stage focuses on designing corrective actions to reduce quality problems. In this study, the improvement proposals focused on standardizing soldering and crimping parameters, improving machine maintenance, controlling operator workload, strengthening inspection activities, and improving workplace lighting in the assembly area.

Control Stage

The Control stage was used to design a control mechanism so that the proposed improvements could be maintained consistently. The proposed control tools were a control plan and a daily check sheet. Putu et al. (2026) explained that the Control stage plays an important role in maintaining improvement results through periodic evaluation, standard operating procedure updates, and process monitoring using quality indicators such as DPMO, sigma level, and defect proportion. In this study, the control plan was designed to monitor critical process points, responsible personnel, control methods, and inspection frequency. The daily check sheet was designed to record daily defect occurrences so that the Quality Control team could detect recurring defects earlier and maintain process stability.

The Measure stage was used to evaluate the actual quality performance of the wiring harness production process. The analysis included defect percentage, DPU, DPO, DPMO, sigma level, Pareto diagram, and p-chart. Zulkhulaifah & Apriliani (2024) stated that DPMO and sigma level can be used to evaluate process capability in Six Sigma. Akbar (2024) also explained that statistical measurement in Six Sigma helps companies evaluate actual process performance. The defect percentage was calculated using Equation (1).

4. RESULTS AND DISCUSSION

Define Stage

The Define stage was conducted to identify the main quality problems in the wiring harness production process. This stage focused on determining the Critical to Quality (CTQ) characteristics that directly affected product conformity. Al-Faritsy (2022) stated that the Define stage in DMAIC is used to identify quality problems and determine the key quality characteristics that must be controlled. Based on field observation and interviews with the Quality Control team, three dominant defects were identified in the wiring harness production process: burned wire, imperfect crimping, and retainer no locking. These defects became the main CTQ because they affected the functional quality of the product and increased rework activities. The CTQ identification is presented in Table 2.

Table 2. Critical to Quality of Wiring Harness Defects.

No.	Defect Type	Defect Description	Production Process
1	Burned wire	The wire was damaged due to excessive or unstable soldering temperature	Soldering
2	Imperfect crimping	The terminal joint was not precise, causing the connection strength between the wire and terminal to be less optimal	Crimping
3	Retainer no locking	The wire component and crimping result were not locked properly	Assembly

Source: Field observation and Quality Control interview, 2025.

Based on Table 2, the three CTQ characteristics represented the main quality problems in the wiring harness production process. Burned wire occurred in the soldering process and was related to temperature control. Imperfect crimping occurred in the crimping process and was related to machine pressure and connection precision. Retainer no locking occurred in the assembly process and was related to installation accuracy and locking inspection. These findings show that the defect sources were not concentrated in one process only but appeared in several critical production stages. This condition indicates that quality improvement should not only focus on final inspection but also control critical production parameters at each process stage where defects are generated.

The CTQ results also show that the quality problem required a process-based improvement approach. Burned wire must be controlled through soldering parameter standardization, imperfect crimping must be controlled through machine pressure stability and inspection, while retainer no locking must be controlled through work method standardization and final checking. Therefore, these three CTQ characteristics became the basis for the next DMAIC stages, especially the Measure stage, where defect proportion, DPMO, sigma level, Pareto analysis, and p-chart were used to evaluate process performance.

Measure Stage

The Measure stage was conducted to evaluate the actual quality performance of the wiring harness production process. This stage used defect data from January to June 2025 to determine the dominant defect types and the priority of improvement. Zulkhulaifah & Apriliani (2024) stated that Six Sigma can measure process performance through defect calculation, DPMO, and sigma level. In this study, the initial measurement was conducted by calculating the proportion of each defect type against the total defects. The recapitulation of wiring harness defect types is presented in Table 3.

Table 3. Recapitulation of Wiring Harness Defect Types.

No.	Defect Type	Total Defect (Unit)	Percentage (%)	Cumulative Percentage (%)
1	Burned wire	1,350	40.06	40.06
2	Imperfect crimping	1,300	38.58	78.64
3	Retainer no locking	720	21.36	100.00
Total		3,370	100.00	

Source: Researcher data processing, 2025.

Based on Table 3, burned wire was the highest defect type with 1,350 units or 40.06% of total defects. Imperfect crimping was the second highest defect with 1,300 units or 38.58%. Retainer no locking contributed 720 units or 21.36%. These results show that burned wire and imperfect crimping were the two main quality problems in the wiring harness production process.

To determine the priority of improvement, the defect data were visualized using a Pareto diagram. The Pareto diagram was used to identify defect types with the largest contribution to the total defects. The Pareto diagram of wiring harness defects is shown in Figure 2.

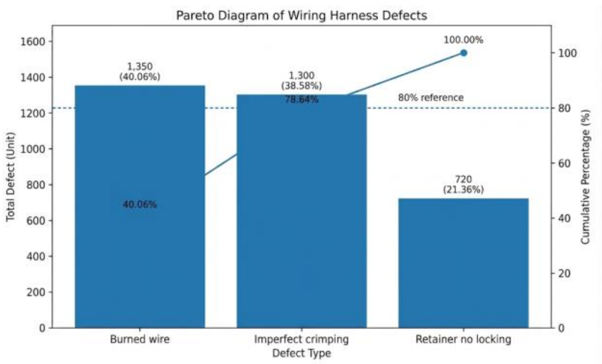

Figure 2. Pareto diagram of wiring harness defects.

Based on Figure 2, burned wire and imperfect crimping contributed 78.64% of the total wiring harness defects. According to the Pareto principle, improvement efforts should prioritize the defect categories with the largest contribution because controlling these defects provides the greatest potential impact on overall quality improvement. Therefore, the soldering and crimping processes became the main improvement priorities in this study. This result indicates that improvement actions should prioritize the soldering and crimping processes because both processes generated the largest defect contribution. Retainer no locking still needs control, but it has a lower priority compared with burned wire and imperfect crimping. Therefore, the next analysis focused on measuring process performance through DPMO, sigma level, and p-chart to evaluate the capability and stability of the production process. The Pareto analysis indicates that improvement efforts should be prioritized on the defect categories with the highest contribution. Based on the 80/20 principle, reducing burned wire and imperfect crimping defects provides the greatest opportunity to decrease the overall defect rate because these two categories represent the majority of quality problems. Therefore, the soldering and crimping processes were identified as critical improvement areas that require further investigation in the root cause analysis stage.

Process Capability Measurement

After the dominant defects were identified through Pareto analysis, the next measurement was conducted to evaluate the capability of the wiring harness production process. This measurement used DPU, DPO, DPMO, and sigma level. Zulkhulaifah & Apriliani (2024) stated that DPMO and sigma level can be used to evaluate process capability in Six Sigma. Akbar (2024) also explained that statistical measurement in Six Sigma helps companies evaluate actual process performance and identify the need for improvement.

In this study, the number of Critical to Quality (CTQ) characteristics was three, namely burned wire, imperfect crimping, and retainer no locking. The following example shows the calculation for January 2025. In January, total production was 10,250 units and total defects were 650 units.

$DPU = \frac{650}{10.250} = 0{,}06341$ .... (ix)

$DPO = \frac{650}{10.250 \times 3} = 0{,}021138$ .... (x)

$DPMO = 0{,}021138 \times 1.000.000 = 21.138{,}21$ .... (xi)

$\text{Sigma Level} = Z\left(1 - \frac{21.138{,}21}{1.000.000}\right) + 1.5 = 3{,}53$ .... (xii)

Based on the calculation example, the DPMO value for January was 21,138.21, with a sigma level of 3.53. The same calculation procedure was applied to the production and defect data from February to June 2025. The complete DPMO and sigma level results are presented in Table 4.

Table 4. DPMO and Sigma Level of Wiring Harness Production

No.	Month	Total Production (Unit)	Total Defect (Unit)	DPO	DPMO	Sigma Level
1	January	10,250	650	0.021138	21,138.21	3.53
2	February	7,300	440	0.020091	20,091.32	3.55
3	March	9,500	580	0.020351	20,350.88	3.55
4	April	8,200	510	0.020732	20,731.71	3.54
5	May	9,350	560	0.019964	19,964.35	3.55
6	June	10,200	630	0.020588	20,588.24	3.54
	Average	9,133	562	0.020500	20,500.00	3.55

Source: Researcher data processing, 2025.

Based on Table 4, the average DPMO value was 20,500.00, with an average sigma level of 3.55. This result indicates that the wiring harness production process was still at a moderate quality capability level and had not reached an optimal Six Sigma performance level. The highest DPMO occurred in January at 21,138.21, with a sigma level of 3.53. The lowest DPMO occurred in May at 19,964.35, with a sigma level of 3.55.

The sigma level values from January to June were between 3.53 and 3.55. This narrow range indicates that the quality problem occurred consistently during the observation period. Therefore, the company needs improvement actions that focus not only on final inspection, but also on process parameter control, machine condition stability, operator workload control, and work method consistency.

P-Chart Analysis

After measuring DPMO and sigma level, a p-chart was used to evaluate the stability of the wiring harness production process. The p-chart was selected because the data used in this study were defect proportion data from each monthly production period. (Muhammad Azis Akbar, 2024) stated that statistical tools in Six Sigma can be used to evaluate process performance and identify quality variation. In this study, the p-chart was used to determine whether the monthly defect proportion was still within the statistical control limits.

The calculation example was taken from January 2025. In January, total production was 10,250 units, total defects were 650 units, and the average defect proportion was 0.0615. The defect proportion for January was calculated as follows.

$$\text{DPU} = \frac{650}{10.250} = 0{,}0634 \ldots\ldots \text{(xiii)}$$

The center line was calculated from total defects divided by total production during the observation period.

$$CL = \frac{3.370}{54.800} = 0{,}0615 \quad \text{(xiv)}$$

The upper control limit and lower control limit for January were calculated as follows.

$$\text{UCL} = 0{,}0615 + 3\sqrt{\frac{0{,}0615(1-0{,}0615)}{10.250}} \quad \text{(xv)}$$

$$\text{UCL} = 0{,}0686$$

$$\text{LCL} = 0{,}0615 - 3\sqrt{\frac{0{,}0615(1-0{,}0615)}{10.250}} \quad \text{(xvi)}$$

$$\text{LCL} = 0{,}0544$$

Based on the calculation example, the defect proportion for January was 0.0634, with a CL of 0.0615, UCL of 0.0686, and LCL of 0.0544. The same calculation procedure was applied to the data from February to June 2025. The complete p-chart calculation results are presented in Table 5.

Table 5. P-Chart Calculation of Wiring Harness Defect Proportion.

No.	Month	Total Production (Unit)	Total Defect (Unit)	Defect Proportion (P)	CL	UCL	LCL
1	January	10,250	650	0.0634	0.0615	0.0686	0.0544
2	February	7,300	440	0.0603	0.0615	0.0699	0.0531
3	March	9,500	580	0.0611	0.0615	0.0689	0.0541
4	April	8,200	510	0.0622	0.0615	0.0695	0.0535
5	May	9,350	560	0.0599	0.0615	0.0690	0.0540
6	June	10,200	630	0.0618	0.0615	0.0686	0.0544
Total / Average		54,800	3,370		0.0615		

Source: Researcher data processing, 2025.

Based on Table 5, the average defect proportion or center line was 0.0615. The highest defect proportion occurred in January at 0.0634, while the lowest occurred in May at 0.0599. The UCL values ranged from 0.0686 to 0.0699, while the LCL values ranged from 0.0531 to 0.0544. These results were then visualized in the p-chart to show the position of monthly defect proportions against the statistical control limits.

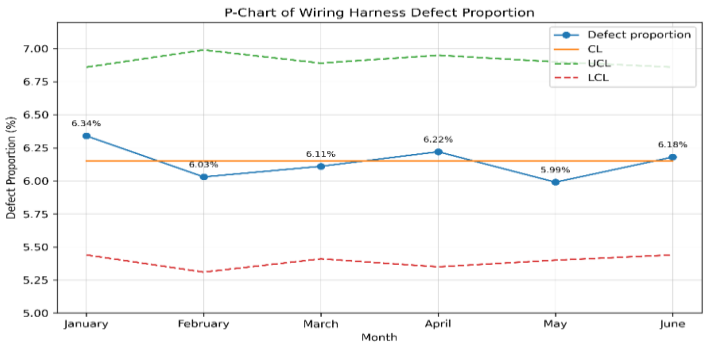

Figure 3. P-Chart of wiring harness defect proportion.

Based on Figure 3, all defect proportion points from January to June 2025 were located between the upper control limit and the lower control limit. This condition indicates that the wiring harness production process was statistically in control. However, the process had not achieved the company quality target because the average defect proportion was 0.0615 or 6.15%, which exceeded the company tolerance limit of 5%.

This result shows that the production process was stable, but stable at a defect level that was still above the company standard. Therefore, the quality problem was not caused by extreme random disturbances in a certain month, but by recurring process conditions. This finding supports the need for root cause analysis in the Analyze stage. The next analysis focuses on identifying the causes of burned wire, imperfect crimping, and retainer no locking using fishbone diagram and 5 Whys analysis.

Analyse Stage

The Analyse stage was conducted to identify the root causes of the dominant defects found in the wiring harness production process. (Al-Faritsy, 2022) stated that the Analyze stage in DMAIC is used to identify the root causes of quality problems and process variation. In this study, the analysis focused on three dominant defects: burned wire, imperfect crimping, and retainer no locking. The root cause analysis was carried out using fishbone diagram and 5 Whys analysis. To keep the discussion concise, the main root causes are summarized in Table 6.

Table 6. Root Cause Analysis of Dominant Defects.

No.	Defect Type	Main Cause Factor	Root Cause	Process Impact
1	Burned wire	Machine and method	Unstable soldering temperature, inconsistent machine maintenance, and no standardized soldering time	Wire damage occurred during the soldering process
2	Imperfect crimping	Machine and method	Unstable crimping pressure, inadequate machine inspection, and inconsistent process standard implementation	Terminal connection did not meet the required specification
3	Retainer no locking	Man, method, and environment	Nonstandard installation process, visual inspection dependency, and inadequate workplace lighting	Retainer was not locked properly during assembly

Source: Researcher data processing, 2025.

Based on Table 6, the dominant defects were mainly caused by machine instability, weak process standardization, limited inspection control, and workplace condition problems. Burned wire was related to soldering temperature instability and the absence of a clear soldering time standard. Imperfect crimping was caused by unstable machine pressure and inadequate machine inspection. Retainer no locking was caused by installation inconsistency, visual inspection dependency, and insufficient lighting in the assembly area. These findings show that the quality problems were not only caused by operator errors, but also by weak control of process parameters, machine conditions, and inspection systems.

Improve and Control Stage

The Improve stage was conducted to develop corrective actions based on the root causes identified in the Analyse stage. Al-Faritsy (2022) explained that the Improve stage focuses on designing corrective actions to reduce quality problems. The improvement proposals in this study were prepared using the 5W+1H approach. Since the article length must remain efficient, the improvement proposal and control mechanism are integrated in Table 7.

Table 7. Improvement Proposal and Control Plan.

No.	Defect Focus	What Should Be Improved	Where and when	Who Is Responsible	How to Control
1	Burned wire	Standardize soldering temperature and soldering time	Soldering process, during daily production	Production supervisor, operator, and engineering team	Set standard soldering parameters, check soldering temperature before production, and record the result in a daily check sheet
2	Imperfect crimping	Improve crimping machine pressure control and inspection	Crimping process, before and during production	Operator, maintenance team, and Quality Control	Conduct machine pressure checks, perform routine machine inspection, and verify crimping results based on the inspection standard
3	Retainer no locking	Standardize retainer installation and improve locking inspection	Assembly and inspection area, during assembly process	Assembly operator and Quality Control	Apply standard installation steps, inspect retainer locking position, and improve lighting conditions in the assembly area
4	Overall process control	Strengthen daily monitoring and documentation	Wiring harness production line, every production shift	Quality Control and production supervisor	Use control plan and daily check sheet to monitor defect trends and detect recurring defects earlier

Source: Researcher data processing, 2025.

Based on Table 7, the proposed improvements focused on controlling the main causes of defects. For burned wire, the improvement focused on standardizing soldering parameters and checking temperature stability. For imperfect crimping, the improvement focused on controlling machine pressure and strengthening inspection before and during production. For retainer no locking, the improvement focused on standardizing the installation process, improving locking inspection, and evaluating workplace lighting. These actions are expected to reduce repeated defects by controlling the process directly at the source.

The Control stage was designed to maintain the consistency of the proposed improvements. (Putu, Dewa Waruna Agung, Anak Agung Istri Agung Sri Komaladewi, 2026) stated that the Control stage plays an important role in maintaining improvement results through periodic evaluation, SOP updates, and process monitoring using quality indicators such as DPMO, sigma level, and defect proportion. In this study, the control mechanism consisted of a control plan and daily check sheet. The control plan was used to monitor critical process points, while the daily check sheet was used to record defect occurrences in each production period. This control mechanism helps the Quality Control team identify recurring defects earlier and supports continuous quality improvement in wiring harness production.

The results of the DMAIC analysis show that the wiring harness production process was statistically controlled, but its average defect percentage still exceeded the company tolerance limit. Therefore, the improvement priority should focus on reducing burned wire and imperfect crimping because both defects contributed 78.64% of total defects. Retainer no locking also needs to be controlled through work method standardization and inspection improvement. Overall, the proposed improvements are expected to help PT Tae Bong Indonesia reduce defect levels, stabilize the production process, and strengthen quality control activities.

5. CONCLUSION AND RECOMMENDATION

This study concludes that the quality performance of wiring harness production at PT Tae Bong Indonesia has not yet met the company's quality standard. The average defect rate of 6.15% exceeds the company tolerance limit of 5%, indicating that the production process still requires systematic improvement. The Six Sigma analysis shows that the process capability is at a moderate level with an average DPMO of 20,500 and a sigma level of 3.55. The dominant defects identified are burned wire, imperfect crimping, and retainer no locking, which contribute significantly to the total defect rate and represent the main focus for quality improvement. The analysis also indicates that although the process is statistically in control, the stability occurs at a defect level that is still above the acceptable standard, suggesting recurring process-related issues rather than random variation. The root causes are mainly associated with unstable machine parameters, inconsistent maintenance practices, non-standardized working methods, and weak inspection control systems. Based on these findings, it is recommended that the company strengthen process standardization, improve preventive maintenance systems, enhance inspection accuracy, and implement a structured control plan supported by continuous monitoring using quality indicators such as DPMO and sigma level. The study is limited to production data from January to June 2025 and does not include post-implementation evaluation of the proposed improvements. Future research is suggested to assess the effectiveness of the implemented improvements by comparing pre- and post-improvement performance to ensure sustainable quality enhancement in wiring harness production.

REFERENCE

Agung, P. D. W., Komaladewi, A. A. I. A. S., & S. (2026). Penerapan metode DMAIC dalam pengendalian kualitas produk cacat pada pabrik Pie Susu Putri. *Riset: Jurnal Edukasi, Multidisiplin, 3*, 486–504.

Akbar, M. A. (2024). Penerapan Six Sigma untuk meningkatkan kualitas dan mengurangi cacat produk. *Circle Archive, 1*, 1–8.

Al-Faritsy, A. Z. (2022). Analisis pengendalian kualitas untuk mengurangi cacat produk tas dengan metode Six Sigma dan Kaizen. *Jurnal Cakrawala Ilmiah, 1*(11), 2733–2744. https://doi.org/10.53625/jcijurnalcakrawalailmiah.v1i11.2855

Al-Faritsy, A. Z., Wahyunoto, A. S., & Industri, J. T. (2022). Analisis pengendalian kualitas produk meja menggunakan metode Six Sigma pada PT XYZ. *Jurnal Rekayasa Industri (JIR), 4*(2), 52–63. https://doi.org/10.37631/jri.v4i2.707

Apri, S. A., Siti Rahayu, & H. W. (2025). Penerapan metode Six Sigma dan FMEA untuk meningkatkan kualitas produk di industri manufaktur otomotif. *Jurnal Kalibrasi, 8*(2), 58–69. https://doi.org/10.37721/kalibrasi.v8i2.1620

Azis, D., & Vikaliana, R. (2023). Pengendalian kualitas produk menggunakan pendekatan Six Sigma dan Kaizen sebagai upaya pengurangan kecacatan produk. *Jurnal InTent, 6*(1), 37–54. https://doi.org/10.47080/intent.v6i1.2596

Badan Pusat Statistik. (2025). *Direktori industri manufaktur Indonesia*.

Basjir, M., Suhartini, & N. R. (2023). Pengendalian kualitas produk plastik menggunakan Six Sigma guna meningkatkan daya saing. *Journal of Research and Technology, 9*(1), 33–46. https://doi.org/10.55732/jrt.v9i1.888

Condé, G. C. P., Oprime, P. C., & Bueno, C. R. (2022). Defect reduction using Lean Six Sigma and DMAIC.

Damayant, K., Fajri, M., & Adriana, N. (2022). Pengendalian kualitas di Mabel PT Jaya Abadi dengan metode Six Sigma. *[Data jurnal tidak lengkap]*.

Fedyawan, I. (2023). Analisis pengendalian kualitas dengan metode Six Sigma pada proses produksi flexible container bag di PT Daiyaplas. *Industrial Engineering Online Journal, 12*.

Firmansyah, R., Kofiyah, N. A., & S. (2025). Pengendalian kualitas dengan metode Six Sigma DMAIC untuk menurunkan cacat produk Block Mesin 4TNV 107 di PT XYZ. *Jurnal Manajemen dan Teknik Industri, 26*(1), 1–10. https://doi.org/10.30587/matrik.v26i1.10108

Fradinata, E., Marsella, B., & Izzaty, N. (2022). Pengukuran produktivitas dengan menggunakan metode Objective Matrix pada proses produksi UD Kopi Teungku Aceh. *Serambi Engineering, 7*(3), 3353–3364. https://doi.org/10.32672/jse.v7i3.4494

Imansuri, F., Chayatunnufus, T., Safril, S., Sumasto, F., Purwojatmiko, B. H., & Salati, D. (2024). Reducing defects using DMAIC methodology in an automotive industry. *Spektrum Industri, 22*(1), 1–13. https://doi.org/10.12928/si.v22i1.171

Khalisan, D., & Hasibuan, A. (2025). Penggunaan metode Six Sigma dalam meningkatkan kualitas produk. *[Data jurnal tidak lengkap]*.

Mabrur, B. H. (2021). Analisis pengendalian kualitas produk keramik menggunakan metode Six Sigma di PT Primarindo Argatile. *Jurnal Ilmiah Teknik dan Manajemen Industri, 1*, 187–200. https://doi.org/10.46306/tgc.v1i2.16

Mahira, Prasetyo Hadi, & H. N. (2021). Pengaruh kualitas produk dan kualitas pelayanan terhadap kepuasan pelanggan IndiHome. *[Data jurnal tidak lengkap]*.

Nanlohy, S. B. A., & Y. E. (2024). Pengendalian kualitas produk menggunakan Six Sigma untuk mengurangi jumlah produk cacat. *Jurnal SENOPATI*, 128–135. https://doi.org/10.31284/j.senopati.2024.v5i2.5331

Putri, H. S., Trirahayu, D., & Hendratni, T. W. (2023). Pengaruh penerapan metode kualitas terhadap produktivitas kerja karyawan. *[Data jurnal tidak lengkap]*. https://doi.org/10.35814/jimp.v3i1.3634

Suhendra, S., & Rahayu. (2025). Implementasi metode Six Sigma untuk peningkatan mutu produk Disc Brake K1A di industri manufaktur otomotif. *Jurnal Kalibrasi*, *9*(1), 31–42. https://doi.org/10.37721/kalibrasi.v9i1.1773

Suprapto, E., & Mahaputra, M. R. (2023). Pengaruh lingkungan kerja dan motivasi terhadap produktivitas kerja karyawan pada PT REMCO Jambi. *Jurnal Manajemen*, *1*(4), 948–955. https://doi.org/10.38035/jim.v1i4.164

Widyaningrum, D., & Al-Faritsy, A. Z. (2026). Analisis pengendalian kualitas produk sarung tangan di PT Adi Satria Abadi menggunakan metode Six Sigma (DMAIC). *Jurnal Multi Disiplin Ilmu Akademik, 3*(1), 538–545.

Yu, C. M., Huang, T. H., Chen, K. S., & Huang, T. Y. (2022). Construct Six Sigma DMAIC improvement model for manufacturing process quality of multi-characteristic products. *Mathematics, 10*(5). https://doi.org/10.3390/math10050814

Zulkhulaifah, J. A., & Apriliani, F. (2024). Penerapan Six Sigma dan metode Define, Measure, Analyze, Improve, Control (DMAIC) untuk analisis Green Tyre Shortage di PT Merpati Putih. https://doi.org/10.56211/factory.v2i3.495