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Analysis of Quality Control Using Quality Control Circle & Plan-Do-Check-Act to Improve The Quality of KTMY Joint Brake Products

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ABSTRACT

Joint Brake KTMY is a safety-critical connector within the motorcycle braking system, yet quality control efforts on this component have received limited attention compared with non-safety-critical automotive parts. This study used a single-site before-and-after case study to evaluate an implemented Quality Control Circle (QCC) integrated with the Plan-Do-Check-Act (PDCA) cycle for Joint Brake KTMY products at PT Ciptaunggul Karya Abadi. Baseline records comprised 30,500 production units and 1,200 targeted defective units; the post-improvement dataset comprised 5,500 production units and 24 targeted defective units. The actions included replacement of worn dies and tapping tools, standardized machine settings, material and hole checks, operator briefings, and inspection check sheets. The targeted-defect proportion decreased from 3.93% to 0.44%, an observed absolute reduction of approximately 3.50 percentage points. Because the comparison had no control group, unequal periods, and possible confounding factors, the result is interpreted as a lower observed post-improvement proportion, not definitive proof of causation or process stability. These findings suggest that standardizing the implemented QCC-PDCA actions into routine work instructions and periodic audits could help sustain quality improvement in safety-critical brake components.

Keywords: *Quality Control Circle, Plan Do Check Act, Defect Rate, Continuous Improvement.*

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INTRODUCTION

In the manufacturing industry, product quality is a critical factor that determines a company's ability to compete in an increasingly competitive market. Companies are required to produce products with the lowest possible defect rate to meet customer expectations, reduce production costs, and improve process efficiency. Product quality is one of the primary criteria considered by customers when selecting products; therefore, it serves as an important indicator of a company's competitiveness and long-term sustainability [1]. However, quality control efforts often encounter various challenges, one of which is the occurrence of defects in manufactured products. A high defect rate can increase rework and scrap costs, reduce productivity, and negatively affect the quality of the final product [2]. Products with consistent quality that meet established specifications can enhance customer trust and satisfaction, whereas products with poor quality may reduce purchasing decisions and weaken the company's competitive position [3].

Defects may occur in the form of dimensional deviations, surface imperfections, or functional nonconformities with the specified product requirements [4]. When these defects occur repeatedly, they contribute to an increase in the number of defective products and a decline in overall quality performance [5], [6], [7]. This condition indicates that quality control should not rely solely on final inspection, but should also adopt a systematic approach that emphasizes continuous process improvement [8].

The integration of Quality Control Circle (QCC) and the Plan-Do-Check-Act (PDCA) cycle has been widely applied to reduce defect rates across manufacturing sectors. Reported applications include roll-cutting accuracy in tissue production [1], defect reduction in garment finishing [4], quality analysis using seven-tools methods in general production lines [5], apparel quality improvement in an Indonesian garment company [6], productivity improvement on a recoiling line [10], and quality-management recommendations for defence-industry components [13], while a related implementation combined QCC and PDCA to reduce free-fatty-acid defects in crude-palm-oil processing [14]. Across these studies, the combination of Pareto prioritization, fishbone root-cause analysis, and 5W1H action planning within the PDCA cycle is consistently associated with a lower observed defect proportion after implementation, although the components involved are largely non-safety-critical, such as textiles, apparel, and general metal or food-grade parts [9], [10].

Despite this body of work, comparatively few QCC-PDCA studies have examined safety-critical automotive braking components, where dimensional or functional defects carry direct implications for vehicle safety rather than only cosmetic or cost consequences [11], [12]. Prior studies also rarely disclose, in a transparent manner, the methodological limitations of their before-and-after comparisons, such as unequal observation periods, the absence of a control group, or potentially confounding production conditions, which restricts how confidently their reported improvements can be interpreted. This leaves a gap in understanding both how QCC-PDCA performs and how its results should be interpreted when applied to a safety-relevant brake component under real single-site production constraints.

To address this gap, the present study applies QCC-PDCA specifically to the Joint Brake KTMY, a connector component within the motorcycle braking system, and reports the targeted-defect proportion before and after implementation alongside an explicit account of the case study's methodological limitations. The novelty of this work lies in combining defect-category quantification through Pareto analysis, fishbone diagrams, ANAKONDA, and 5W1H with a single-site before-and-after design applied to a safety-critical automotive part, and in framing the observed reduction as an interpretable case-study finding rather than a generalizable causal claim.

PT Ciptaunggul Karya Abadi is a manufacturing company specializing in automotive components. Established in 1998, the company produces various motorcycle spare parts, one of which is the Joint Brake KTMY. This component functions as a connector between the brake pedal and the brake rod, brake cable, or brake cam, while also reducing friction and misalignment within the braking system to ensure smooth and optimal braking performance. Considering its important role, the quality of the Joint Brake KTMY must be carefully maintained. Defects in this component may cause irregular braking movement, delayed brake return (dragging), and accelerated wear of other brake components, ultimately reducing vehicle performance and safety.

According to the company's quality policy, PT Ciptaunggul Karya Abadi has established a production quality target of zero defects or the lowest possible defect rate within the specified tolerance limits. However, defect percentage data collected during the September–February period indicate that the actual defect rate remains significantly higher than the expected target. These findings reveal a gap between the company's expected quality standards and the actual quality performance of the Joint Brake KTMY product. Therefore, a systematic analysis and continuous improvement effort are required to reduce the defect rate and enhance product quality performance.

October recorded 750 defective units from 8,000 production units (9.38%), while December recorded 227 defective units from 1,500 production units (15.13%). These peaks are treated as signals for further investigation; the higher December rate is not attributed to low production volume alone. Possible changes in material lots, machines, operators, shifts, product mix, process parameters, and inspection intensity must be checked against company records.

Preliminary observations conducted in the production area revealed several recurring defects in the Joint Brake KTMY product, including surface scratches, dimensional nonconformities, and tight screw conditions, resulting in product finishing that failed to meet the company's quality standards. These defects may be attributed to several contributing factors, including suboptimal working methods, unstable machine conditions, inconsistent material quality, and insufficient operator accuracy during the production process. If left unaddressed, these problems may increase rework costs, generate material waste, reduce production efficiency, and increase the risk of delays in fulfilling customer orders.

These findings indicate that a systematic analysis of potential causes, followed by documented improvement and follow-up, is required. Fishbone analysis identifies hypotheses; it does not by itself prove causation. Building on the gap and novelty described above, this study used a single-site before-and-after case study design. The objectives of this study were to: (1) identify and quantify Joint Brake KTMY defect categories; (2) prioritize defects using Pareto analysis while considering frequency and safety relevance; (3) formulate and implement QCC-PDCA improvement actions; and (4) evaluate the observed change in the proportion of three targeted defect categories between the baseline and post-improvement periods. The measurable research question was whether the targeted-defect proportion was lower after implementation.

MATERIAL AND METHOD

Research Time and Location

This study was conducted over a six-month period, from January to June 2026, at PT Ciptaunggul Karya Abadi, located in Purwadana Village, East Telukjambe, Karawang Regency, Indonesia. The company operates in the automotive component manufacturing industry, producing various types of motorcycle spare parts, as well as manufacturing tools and melds (jigs) [13], [14], [15].

Data Collection Techniques

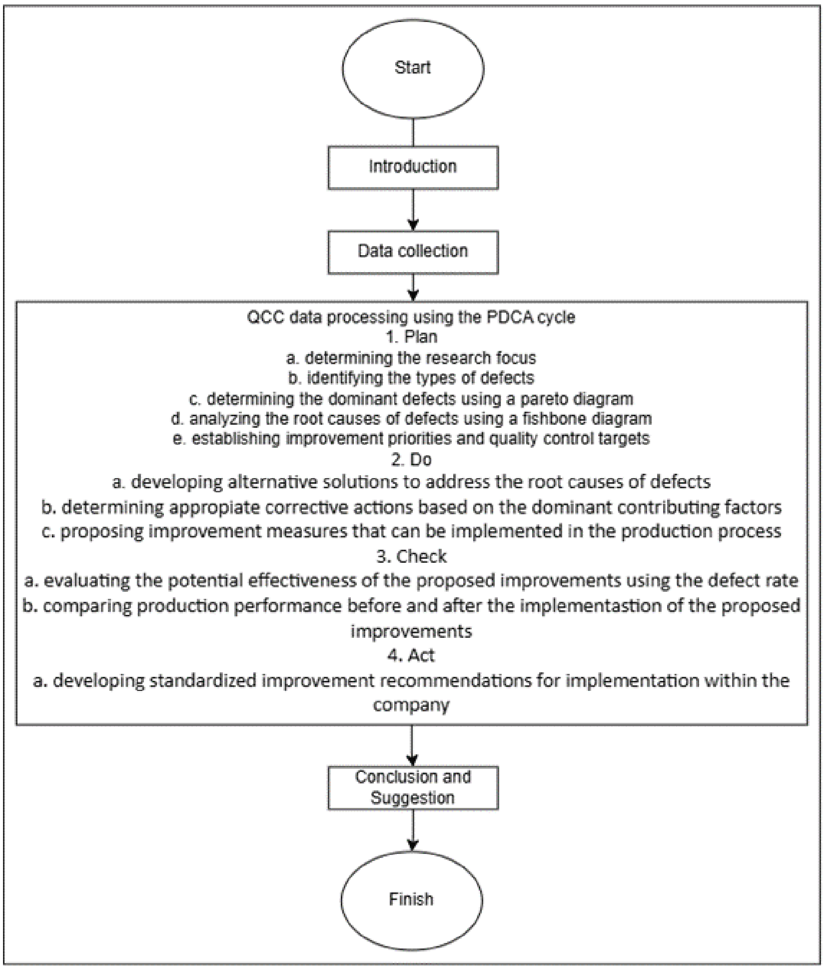

Figure 1. Research procedure

Data consisted of secondary company production and inspection records and primary field observations/interviews. The baseline records (September 2025-February 2026) were checked against production and quality-control recapitulations. Observations examined blanking/cutting, tapping, material handling, machine settings, and inspection. Interviews involved production operators, a production supervisor, engineering, and quality control personnel selected because of their direct responsibility for the process [16], [17]. The manuscript should be read with the limitation that exact participant counts, observation duration, calibration records, and inter-inspector agreement were not documented in the available records.

Data Analysis

The data were analyzed descriptively using defect counts, production quantities, defect proportions, Pareto analysis, ANAKONDA, fishbone analysis, and 5W1H. "Defective unit" means a product rejected during inspection; "defect occurrence" means an observed nonconformity, and one unit may contain more than one occurrence. Burr, blank-minus, non-smooth thread, misalignment, dent, atari, rust, and dull plating were treated as separate categories according to the company inspection terminology [18], [19]. The available dataset does not permit a complete measurement-system analysis or a statistically stable-process claim. A future study should use a p-chart for defective/non-defective units or a u-chart when multiple defects per unit are counted, together with a two-proportion test and 95% confidence interval [20], [21].

Plan

The Plan phase focused on identifying the initial quality problems associated with the Joint Brake KTMY product through the following activities:

- Determining the research theme and collecting production and defect data during the observation period.
- Identifying the types of defects occurring in the production process.
- Determining the dominant defects using a Pareto diagram.
- Analyzing the root causes of defects using a cause-and-effect (fishbone) diagram based on the 4M + 1E (Man, Machine, Material, Method, and Environment)
- Establishing improvement priorities and quality targets to reduce the defect rate.

Do

The Do phase documented the actions implemented after QCC discussion: worn dies and tapping tools were replaced; machine and stopper settings were standardized through Work Instructions; material and hole-cleaning checks were added; pre-shift briefings and lot inspection check sheets were introduced; and machine-area cleaning was assigned to operators [22], [23]. The available records do not provide complete implementation dates, cycle limits, parameter values, or approval signatures; these should be appended by the company before publication.

- Developing alternative solutions to eliminate the identified root causes of defects.
- Determining appropriate corrective actions for the dominant contributing factors (Man, Machine, Material, Method, and Environment).
- Describing the proposed improvement measures that can be implemented in the Joint Brake KTMY production process.

Check

The Check phase compared the targeted-defect count in the baseline dataset (1,200 units from 30,500 production units) with the post-improvement dataset (24 units from 5,500 production units). Because the periods differ in length and production conditions, the comparison is interpreted as an observed change rather than proof that the intervention alone caused the reduction. The calculation was 1,200/30,500 = 3.93% and 24/5,500 = 0.436%, rounded to 0.44%.

- Assessing the potential effectiveness of the proposed improvement measures in reducing the defect rate.
- Comparing production performance before and after improvement using the defect rate.

$$\mathrm{DR} = \frac{\mathrm{D}}{\mathrm{P}} \times 100\% \tag{1}$$

DR = Defect rate
D = Total detective units
P = Total production units

Act

The Act phase focused on standardization and continuous improvement through the following activities:

- Developing recommendations for implementing the proposed improvements within the company.
- Establishing standardized production procedures to maintain product quality.
- Proposing continuous improvement initiatives to prevent the recurrence of similar defects.

RESULTS

The defect data obtained from PT Ciptaunggul Karya Abadi indicate that the Joint Brake KTMY production process still experienced a relatively high number of defective products during the September 2025–February 2026 period. These findings indicate that the product defect rate fluctuated throughout the observation period, suggesting that the production process had not yet consistently met the quality standards established by the company. A high number of defective products may lead to reduced product quality, increased production costs due to rework, and a potential decline in customer satisfaction. Therefore, more effective quality control measures are required to identify and minimize the root causes of defects, thereby supporting the continuous improvement of Joint Brake KTMY product quality.

Table 1. Defect data Joint Brake KTMY

Defect	Total	%	Acc %
Burr	560	35.2	35.2
Blank minus	400	25.2	60.4
Non-smooth thread	240	15.1	75.5
Misalignment	150	9.4	85.0
Dent	90	5.7	90.6
Atari	65	4.1	94.7
Rust	50	3.1	97.9
Dull plating	34	2.1	100.0

In the Quality Control Circle (QCC) method, the Pareto diagram is used to determine problem priorities based on the 80/20 principle [24]. The Pareto diagram consists of a bar chart arranged in descending order of frequency and a cumulative percentage line graph, enabling the identification of the most significant defect categories that should be prioritized for improvement [25].

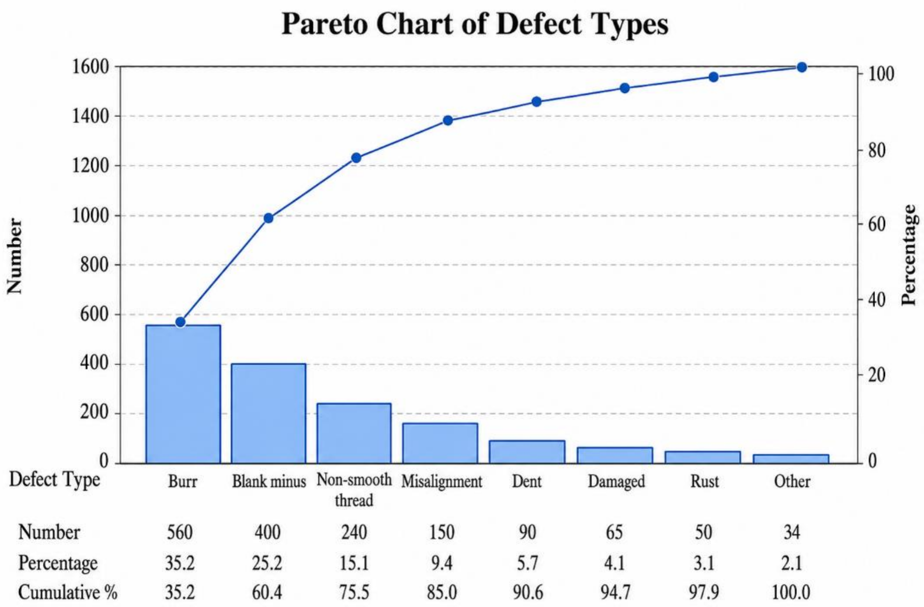

Figure 2. Pareto diagram defect Joint Brake KTMY

At figure 3, the Pareto diagram indicates that a total of 1,589 defective units were identified in the Joint Brake KTMY production process during the September 2025–February 2026 period, comprising eight different defect types. Burry was the most frequently occurring defect, accounting for 560 defects (35.2%), followed by Blank Minus with 400 defects (25.2%), and Ulir Tidak Seret with 240 defects (15.1%). Collectively, these three defect categories contributed 75.4% of the total defects recorded during the observation period. The remaining defect types consisted of Tidak Sejajar with 150 defects (9.4%), Penyok with 90 defects (5.7%), Atari with 65 defects (4.1%), Karat with 50 defects (3.1%), and Buram Plating with 34 defects (2.1%), each occurring at a considerably lower frequency than the three dominant defect categories.

According to the Pareto principle, Burry, Blank Minus, and Ulir Tidak Seret were identified as the highest-priority defects because they collectively accounted for approximately 75.4% of all defects. Therefore, this study focuses the Quality Control Circle (QCC) analysis on these three dominant defect categories to identify their root causes and formulate appropriate improvement measures. By prioritizing the most significant defects, the proposed corrective actions are expected to be more effective and provide a greater contribution to improving the quality of the Joint Brake KTMY product.

Plan

Theme Selection

Based on the defect data collected during the observation period, three dominant defect types were identified, namely Burry**,** Blank Minus**,** and Ulir Tidak Seret. These defects contributed the largest proportion of the total product defects and were therefore identified as the primary priorities for quality improvement. Accordingly, this study focuses on improving product quality by reducing the occurrence of these dominant defects. Improvement priorities were established based on the Pareto principle, which emphasizes addressing approximately 80% of the total quality problems by focusing on the few defect categories that contribute most significantly to the overall defect rate.

Analysis of Existing Conditions (ANAKONDA)

ANAKONDA is one of the stages in the Quality Control Circle (QCC) method used to assess the actual conditions of quality problems based on factual data obtained from the production process. This stage aims to identify the existing conditions through data collection, direct process observation, and analysis of the identified defects, thereby providing a clear understanding of the quality issues that require improvement. The results of the ANAKONDA analysis serve as the basis for determining improvement priorities, establishing quality improvement targets, and conducting root cause analysis using a fishbone diagram. Therefore, the ANAKONDA stage plays an important role in ensuring that improvement activities are carried out based on actual production conditions and reliable data, enabling the proposed corrective actions to be implemented more effectively to improve both process and product quality [26].

Table 2. Analysis of Existing Conditions (ANAKONDA)

Factor	Analysis	Current Condition	Ideal Condition	Remarks
Machine	Observing the production process of Joint Brake KTMY	Worn dies Cutting results do not meet specifications	Sharp dies that comply with standards Stable press machine settings	Affects the final product quality

Man	Observing operator performance during the production process	Burry blank minus ulir tidak seret	No Burry defects No Blank Minus defects Ulir Seret complies with quality standards	Affects the final product quality
Material	Observing whether the raw materials comply with the company's quality standards	Rust found on the material Dented material	Rust-free material Blank dimensions comply with specifications	Affects the final product quality
Methode	Observing production operators and work methods	Incorrect material positioning, process parameters do not comply with standards	Process parameters comply with the established work standards	Affects the final product quality
Environment	Observing the surrounding production environment	Presence of fiber residues from the broaching/tapping	Production area is free of fiber residues Work area is clean and well maintained	Affects the final product quality

Cause and Effect Analysis

The cause-and-effect analysis was conducted using a fishbone diagram based on the ANAKONDA findings. The diagram identifies potential causes rather than proving causation; verification requires machine, tooling, material, operator, shift, and inspection evidence.

The fishbone diagram was developed by classifying the potential causes into five major categories: Man, Machine, Material, Method, and Environment. The fishbone diagram, also known as the cause-and-effect diagram, is a quality management tool used to visualize the root causes of a problem and systematically identify the possible factors contributing to its occurrence [25]. It illustrates the relationship between the identified problem (effect) and its potential causes (causes), thereby facilitating a structured root cause analysis. By applying the fishbone diagram, quality control efforts can focus on addressing the underlying causes of quality problems rather than merely treating their symptoms. Previous studies have demonstrated that the fishbone diagram is effective in identifying and classifying the primary causes of product defects, thereby facilitating the development of appropriate corrective actions [27].

The fishbone analysis identified potential contributing factors in the Machine, Man, Material, and Method categories for the burr defect. These factors require verification through machine records, tool age, material lots, operator and shift data, and inspection evidence before they can be called root causes.

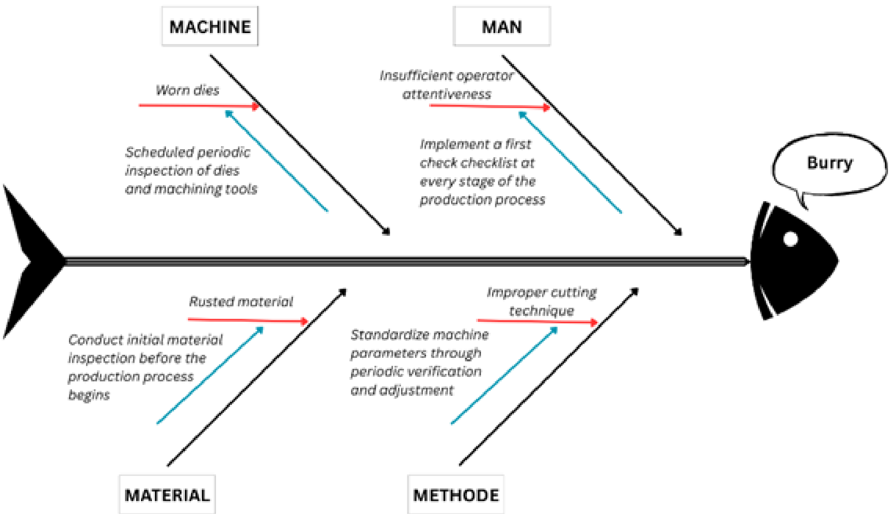

Figure 1. Fishbone diagram burry defect

The fishbone analysis identified potential contributing factors in the Machine, Man, Material, and Method categories for the burr defect. These factors require verification through machine records, tool age, material lots, operator and shift data, and inspection evidence before they can be called root causes.

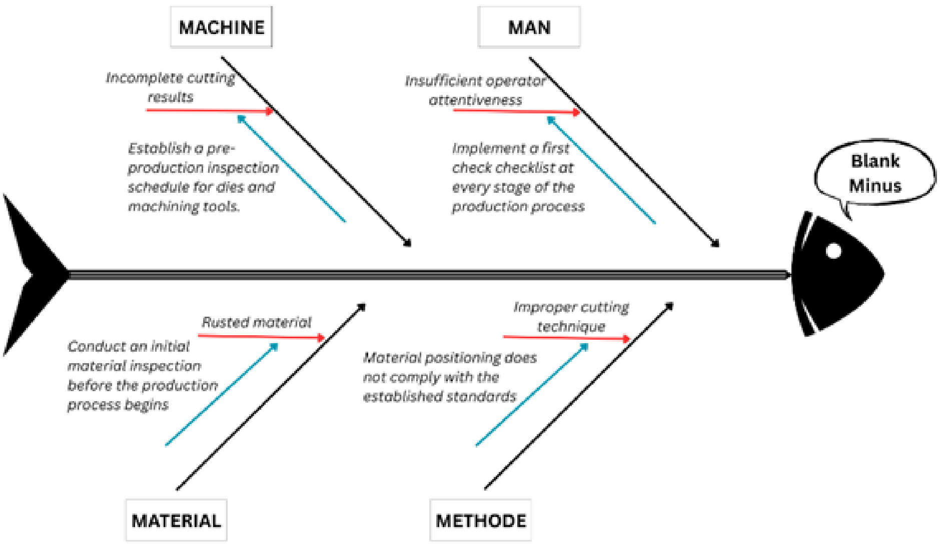

Figure 2. Fishbone diagram defect blank minus

The fishbone analysis identified potential contributing factors in the Machine, Man, Material, Method, and Environment categories for the non-smooth-thread defect. These factors require verification through machine records, tool age, material lots, operator and shift data, and inspection evidence before they can be called root causes.

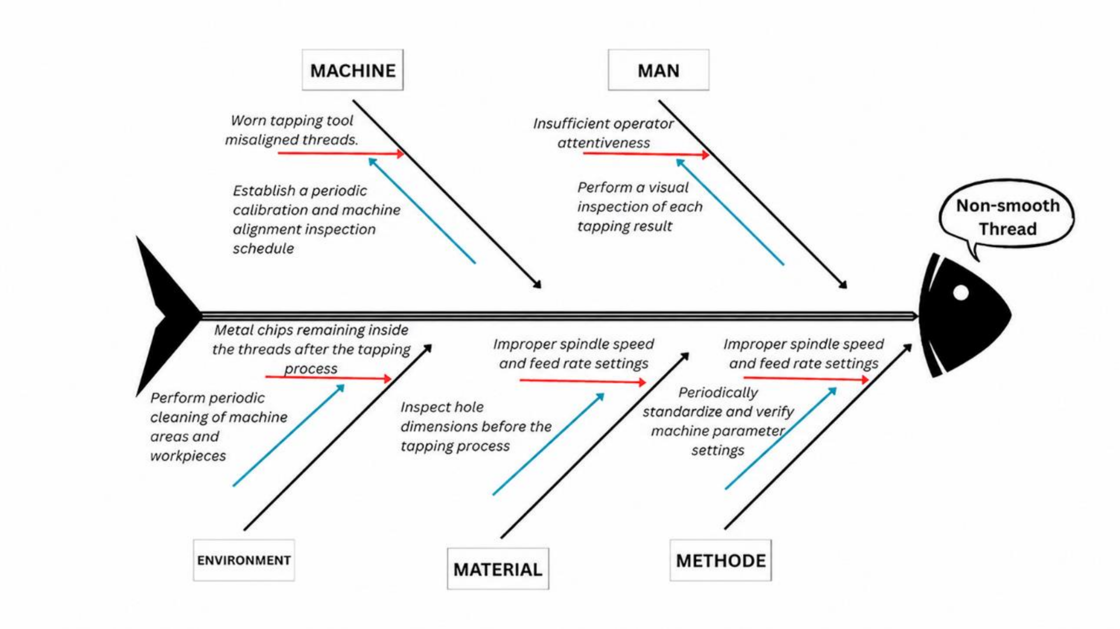

Figure 3. Fishbone diagram defect the non-smooth thread

Do

Based on the root cause analysis conducted using the fishbone diagram, quality control improvement measures were subsequently developed using the 5W1H method. This method was applied to ensure that each proposed corrective action has a clearly defined objective, a systematic implementation procedure, and designated responsibilities, thereby facilitating the effective implementation of improvement initiatives [28]. The improvement proposals were formulated based on data obtained through direct observation of the Joint Brake KTMY production process, during which each stage of the production process was carefully examined to identify opportunities for quality improvement.

5W1H Burry Defect

Table 3. Recommendation improvenet burry defect

Factor	What	Why	Where	When	Who	How
Machine	Worn Dies	Lack of periodic maintenance	Engineering	During production	Engineering	Replace worn dies, perform periodic preventive maintenance

Man	Insufficient operator attentiveness	Production checklist is not consistently implemented	Production area	During production	Supervisor	Supervise operators and conduct each shift pre-shift briefings
Material	Rusted material	Inadequate material inspection	Warehouse & production	Before production	Quality control	Strengthen material inspection before the material is released for production
Method	Improper cutting technique	Inappropriate machine parameter settings	Production area	Before production	Engineering	Periodically standardize and verify machine parameter settings

5W1H Defect Blank Minus

Table 4. Recommendation improvement blank minus defect

Factor	What	Why	Where	When	Who	How
Machine	Incomplete cutting results	Worn dies	engineering	During production	Engineering	Replace worn dies and perform periodic preventive maintenance.
Man	Insufficient operator attentiveness	Production checklist not consistently implemented	Production area	Every shift	Supervisor	Enhance operator supervision and conduct each shift pre-shift briefings
Material	Rusted material	Inadequate material inspection	Warehouse & production	Before production	Quality Control	Conduct material inspection after the blanking process before the material proceeds to the next production stage
Methode	Improper material positioning against the stopper	Improper cutting technique	Production area	Before production	Engineering	Standardize stopper settings and process parameters.

5W1H Non-Smooth Thread

Table 5. Recommendation improvement non-smooth thread

Factor	What	Why	Where	When	Who	How
Machine	Worn tapping tool	Lack of periodic machine calibration	engineering	During production	engineering	Calibrate the machine at a documented frequency and replace worn tapping tools
Man	Insufficient operator attentiveness	Inadequate inspection of tapping results	Production area	Every shift	Supervisor	Enhance operator supervision and perform visual inspections of each tapping result.
Material	Contaminated material holes	Inadequate cleaning process	Production area	Before tapping process	Operator production	Clean the holes and remove metal chips before the tapping process
Method	Improper tapping parameters	Non-standard spindle speed and feed rate settings	Production area	Before production	Engineering	Standardize tapping parameters in accordance with the Work Instruction (WI)
Environment	Unclean work area	Inadequate routine cleaning	Tapping area	After production	Operator production	Clean the machine area, workpieces, and metal chips at a documented frequency

Check

The Check phase compared the targeted-defect count in the baseline dataset (1,200 units from 30,500 production units) with the post-improvement dataset (24 units from 5,500 production units). Because the periods differ in length and production conditions, this is interpreted as an observed before-and-after change, not proof that the intervention alone caused the reduction.

Table 6. Defect data after improvement

Defect	Total	%	Acc %
Burry	11	45,8	45,83
Blank minus	8	33,3	79,16
Ulir tdk seret	5	20,8	100
Total	24		

The targeted-defect proportion decreased from 3.93% before improvement to 0.44% after improvement: an absolute reduction of approximately 3.50 percentage points and a relative reduction of approximately 88.9%. This result describes the audited datasets only. It does not establish statistical process stability, overall defect reduction, or a causal effect because there was no control group, the periods were unequal, and potentially confounding production conditions were not fully controlled.

Act

During the Act phase, the QCC team recommended that the completed actions be incorporated into controlled Work Instructions and audited through: pre-production machine checks before every lot; preventive maintenance at a documented cycle or monthly interval; material and hole inspection using a defined sample size; pre-shift briefings each shift; and weekly compliance review by production, engineering, and quality control. Items that lack formal approval or audit evidence remain recommendations rather than verified standardization.

- Establish a periodic preventive maintenance schedule for the press machine, dies, and tapping tools to prevent wear that may result in Burry, Blank Minus, and thread binding defect.
- Develop a pre-production machine inspection checklist to ensure that all machine parameters comply with the company's established operating standards before production begins.
- Implement a sampling inspection check sheet for each production lot to facilitate material inspection by production operators and the Quality Control Department, ensuring that the materials are free from rust, dents, and dimensional nonconformities before use.
- Conduct pre-shift briefings for production operators to reinforce process parameters, proper operating techniques, and the potential causes of product defects.
- Establish a standardized Work Instruction (WI) covering machine parameter settings, material positioning, and tapping procedures to ensure consistent operating practices among all production operators.
- Maintain workplace cleanliness by periodically removing machining chips from the work area to prevent defects in subsequent production processes.
- Maintain workspace cleanliness by periodically removing machining chips to prevent defects in subsequent processes.

DISCUSSION

The findings of this study show that implementing a Quality Control Circle integrated with the Plan Do Check Act cycle on the Joint Brake KTMY product reduced the targeted-defect proportion from 3.93 percent to 0.44 percent, a relative reduction of approximately 88.9 percent, through improvements addressing three dominant defect categories, burr, blank minus, and non-smooth thread, which together accounted for 75.5 percent of all recorded defect occurrences [29], [30]. These findings need to be placed within the broader QCC, PDCA, and Six Sigma DMAIC literature to assess how far this result aligns with common patterns in manufacturing industries, while also identifying where this study offers a distinct contribution [31], [32].

When compared with the study by Realyvásquez Vargas and colleagues published in Applied Sciences in 2018, the application of PDCA to the welding process of electronic boards in Mexico reduced defects by 65, 79, and 77 percent across three different product models. The magnitude of reduction achieved in the present study falls within the same range, even slightly higher, suggesting that combining Pareto analysis, fishbone diagrams, and 5W1H within a PDCA cycle tends to produce large improvements when applied to processes that previously lacked a structured quality control system [33], [34]. A similar pattern appears in a study on QCC implementation in an Indonesian automotive crankshaft industry, which reported a reduction in rejection rate from 35 percent to just 5 percent following the introduction of an additional machine calibration step after tool changes. This shared pattern reinforces the argument that a sharp decline during the early stage of an improvement cycle is not unique to this study's object, but rather a general characteristic of QCC implementation on processes whose baseline condition is far from standard, leaving considerable room for improvement.

A somewhat different pattern emerges when this study is compared with research on automotive logistics by Amaral, Ferreira, and Ramos published in the Business Systems Research Journal in 2022, as well as a study applying an eight-step, seven-tool PDCA approach to an Indonesian automotive component that cut production cycle time from 49 to 38.9 seconds, a 21 percent reduction. Both of these studies focused on process efficiency and cycle time rather than defect proportion alone, showing that the PDCA framework is flexible enough to be directed toward various performance indicators, not limited to product defect reduction [35], [36]. This provides useful context for understanding that the present study deliberately focused on defect proportion as its success metric, a choice that makes its results more directly comparable with classic QCC studies than if efficiency or cost indicators had been chosen instead.

When this study is set alongside the group of studies using Six Sigma DMAIC, the difference in approach becomes more apparent. Gupta, Jain, Meena, and Dangayach, writing in the Journal of Industrial Engineering International in 2017, reported improvements in a tire manufacturing plant in the form of a reduced process standard deviation, from 2.17 to 1.69, along with an increase in the process capability index Cpk from 0.94 to 2.66. Likewise, a study on aluminum die casting for a two-stroke engine oil pump component achieved a reduction in rejection rate from 17.22 percent to 4.8 percent with the help of Taguchi experimental design, and a study on the welding process of Colt Diesel trucks by [37], [38] complemented Pareto analysis and 5W1H with DPMO and sigma level calculations. These three studies show that Six Sigma DMAIC approaches generally go further than simply comparing before and after defect proportions, incorporating more statistically rigorous process capability measures. The present study has not reached that stage due to data limitations, so its comparison remains descriptive, expressed as a difference in defect proportion rather than a statistically verified process capability analysis. This gap is consistent with the limitations already acknowledged in the methods section, and represents one of the clearest directions for future research, for instance by applying p-charts or u-charts together with a two-proportion test as already suggested.

A more fundamental point of distinction lies in the type of component under study. Most of the comparison studies, whether using QCC or Six Sigma, were applied to components whose failure affects cosmetic quality, cost, or production efficiency, such as electronic boards, beverage packaging, tires, or rotogravure cylinders for flexible packaging. The study [39], [40], [41], stands out as one of the few relevant comparisons because it addressed a cooling fan assembly in helicopter manufacturing, a component whose failure has a direct bearing on flight safety. However, that study stopped at the root-cause identification stage through the Define, Measure, and Analyze phases, without reporting complete quantitative data from an implemented improvement. The present study fills that gap by presenting a full cycle, from defect identification and root-cause analysis through the implementation of corrective actions to quantitative verification of results before and after, applied to a Joint Brake component that is likewise safety-critical for motorcycle riders. Interestingly, when this study's final result of 0.44 percent is compared with a QCC study on quality control of hospital laboratory specimens, which reported a defect rate falling from 0.98 percent to 0.45 percent, the two endpoints are remarkably close despite coming from entirely different sectors. This closeness suggests that a defect proportion around half a percent tends to be regarded as a practically controlled threshold across various types of industries, rather than something specific to one sector, although more cross-sector evidence would be needed to confirm this as a general pattern.

In terms of methodological caution, this study demonstrates an attitude that is relatively uncommon among the comparison studies. Most of them, including a study on stamping defects in a roof rail component that combined QCC with Failure Mode and Effect Analysis, and a study on rotogravure cylinders for flexible packaging, reported defect reduction as direct evidence of the method's success without discussing possible confounding factors such as changes in production volume, operator turnover, or material lot variation between the before and after periods [42], [43], [44]. This study explicitly states that its comparison lacks a control group and involves unequal observation periods, so the observed defect reduction is interpreted as a change that occurred, not as definitive causal proof. This stance aligns with the scientific rigor that industrial case studies should carry, and stands as one of this study's methodological contributions amid the tendency of many similar studies to oversimplify their success claims.

CONCLUSION

The study found eight types of defects in Joint Brake KTMY production during the September 2025 to February 2026 period, totaling 1,589 defect occurrences consisting of burr, blank minus, non-smooth thread, misalignment, dent, atari, rust, and dull plating. Second, regarding defect prioritization using Pareto analysis, the study established burr at 35.2 percent, blank minus at 25.2 percent, and non-smooth thread at 15.1 percent as the three dominant defects, together accounting for 75.5 percent of all recorded occurrences, making them the primary focus for improvement even though the first three categories did not strictly reach the 80 percent Pareto threshold. Third, regarding the formulation and implementation of QCC-PDCA improvement actions, the study traced root causes through ANAKONDA and fishbone diagram analysis across the machine, man, material, method, and environment factors, then translated these into concrete actions through 5W1H, including replacing worn dies and tapping tools, standardizing machine parameters through Work Instructions, strengthening material and hole inspection, conducting pre-shift operator briefings, and implementing production inspection check sheets. Fourth, regarding the evaluation of change in the proportion of the three targeted defect categories between the baseline and post-improvement periods, the results showed a decrease from 3.93 percent across 30,500 production units to 0.44 percent across 5,500 production units, an absolute reduction of approximately 3.50 percentage points and a relative reduction of approximately 88.9 percent. The research question posed, namely whether the targeted-defect proportion was lower after implementation, is therefore answered affirmatively based on the audited data examined in this study. Nonetheless, given that the research design was a single-site case study without a control group and with unequal observation periods, this result should be understood as an observed change in defect proportion under actual production conditions, rather than as generalizable causal proof or a guarantee of long-term statistical process stability.

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