Dinamika Teknik Mesin 15(2) (2025) 167-177

Dinamika Teknik Mesin
Jurnal Keilmuan dan Terapan Teknik Mesin
http://dinamika.unram.ac.id/index.php/DTM/index

Kaizen implementation to reduce dimensional defect in the welding process of fender D155A-6R at PT Arkha Jayanti Persada

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ARTICLE INFO

Article History:
Received 21 August 2025
Accepted 04 September 2025
Available online 01 October 2025

Keywords:
Kaizen implementation
Plan do check action
Improvement
Dimensional defect
Welding process

ABSTRACT

Kaizen is a concept of continuous improvement that emphasizes quality enhancement and efficiency in production processes. In this study, the Kaizen approach was applied to address dimensional defects in the welding process of the Fender D155A-6R component at PT. Arkha Jayanti Persada. The component, which was previously imported from Japan, is currently being tested through local production trials. Initial inspection indicated that 11 of 33 measurement points were out of tolerance, most of which were linked to welding activities. To analyze the problem, the PDCA (Plan, Do, Check, Act) cycle was employed. The investigation revealed several contributing factors: the absence of a locator to secure parts during welding, insufficient reinforcement that caused deformation, and the lack of a standardized welding procedure for operators. Corrective measures were then introduced, including the installation of a locator, additional reinforcements, and the establishment of a formal welding procedure. After two PDCA cycles, the dimensional issues were successfully resolved. The findings indicate that applying Kaizen through PDCA led to significant improvements in dimensional accuracy and product quality.

Dinamika Teknik Mesin, Vol. 15, No. 2 Oktober 2025, ***p. ISSN: 2088-088X, e. ISSN:*** **2502-1729**

1. INTRODUCTION

The heavy equipment manufacturing industry in Indonesia has experienced significant growth. This growth is in line with the increasing demand for construction and mining machinery. PT. Arkha Jayanti Persada is a manufacturing company specializing in the production of heavy equipment components and serves as one of the main suppliers to PT. Komatsu Indonesia. One of the products developed by PT Komatsu Indonesia for local production is the fender for the Dozer D155A-6R unit. However, as a new product still in the trial production phase, several quality issues have been identified, particularly dimensional defects occurring during the welding

https://doi.org/10.29303/dtm.v15i2.1158

process. According to Andita et al. (2025), defects in a product can affect both quality and production efficiency, which may harm the company; therefore, immediate corrective actions are necessary.

Jannah and Hayuningtias (2024) stated that product quality is one of the key elements that can enhance customer satisfaction. According to Adawia and Azizah (2020), overall efficiency, quality, and performance can be improved through Kaizen, or continuous improvement, which is carried out gradually in stages. Similarly, Pangestu et al. (2025) emphasized that implementing Kaizen through a systematic method such as the PDCA (Plan–Do–Check–Act) cycle is highly effective in improving product quality.

Based on the study by Fatah and Al-Faritsy (2021), the implementation of PDCA in the home electronics industry (refrigerators) reduced production defects from 59.45% to 36.50%. Meanwhile, Widianto et al. (2025) reported that PDCA implementation in the automotive industry decreased black spot defects on assy water products from 9% to 1%. In the packaging sector, Nguyen et al. (2020) found that PDCA reduced damage to fragile products weighing ≤15 kg, achieving a 100% pass rate in drop tests. Rajić et al. (2024) reported that the circular economy model based on PDCA is still largely limited to managerial and business planning aspects, with 58.52% of organizations not reaching 50% implementation and none fully applying the model.

Research on the application of PDCA to improve production quality in the heavy equipment industry is still very limited. Unlike electronics or automotive products, heavy equipment products are much larger and more complex. In particular, the differences include size, material, and tolerance. As a result, these unique factors create challenges that cannot simply be compared to other industries. Therefore, this study aims to address that gap. Specifically, it examines the use of a Kaizen approach based on the PDCA cycle in the welding process of the Fender D155A-6R. The study provides empirical evidence of PDCA's effectiveness in a rarely researched sector.

2. RESEARCH METHODS

This study employed an experimental approach by applying Kaizen as a method of continuous improvement. The process was carried out through the PDCA (Plan, Do, Check, Action) cycle. According to Rangel-Sánchez et al. (2024), PDCA demonstrates strong compatibility with various tools and methods that support continuous improvement. In the context of manufacturing, the PDCA cycle plays an important role in Kaizen because it provides a clear and structured methodology. In this study, the improvement activities were systematically arranged and followed the principles of PDCA within a specific time frame. To carry this out, Nguyen et al. (2020) explained that PDCA consists of four stages: identifying problems and setting improvement targets (Plan), implementing the proposed solutions (Do), evaluating the results (Check), and finally taking follow-up actions or applying standardization if the targets were achieved (Action).

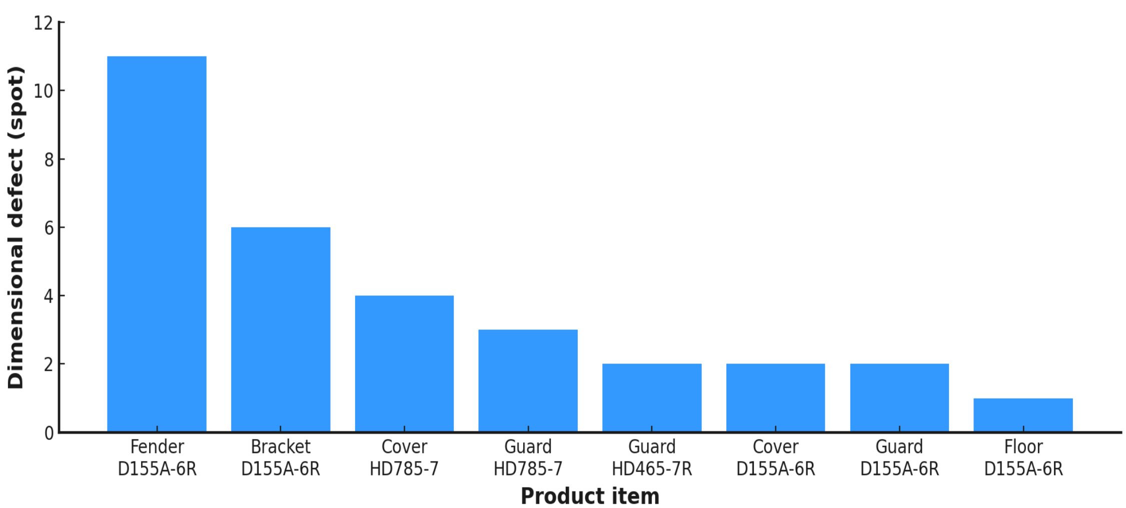

Figure 1. Products with dimensional defects in PT. Arkha Jayanti Persada.

The welding quality of the fender component D155A-6R has been problematic, particularly with dimensional deviations. In practice, operators often still set the seat position using rulers. Rulers are prone to reading errors, which can cause operators to misalign the seat position. As a result, the seat dimensions after welding fail to conform to the engineering drawings. Another contributing factor is the absence of

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reinforcements and the lack of standardized welding procedures. Both of these increase the risk of deformation and eventually result in dimensional inaccuracies.

Based on the problem identification, the Fender D155A-6R showed the highest number of dimensional defects during the production trial at PT. Arkha Jayanti Persada (Figure 1). Of the 33 measured points, 11 were defective, marked with red triangles, while the rest met specifications and were marked with green triangles (see Figure 2). These defects indicate deviations from the technical drawing specifications, requiring systematic corrective actions to improve product quality.

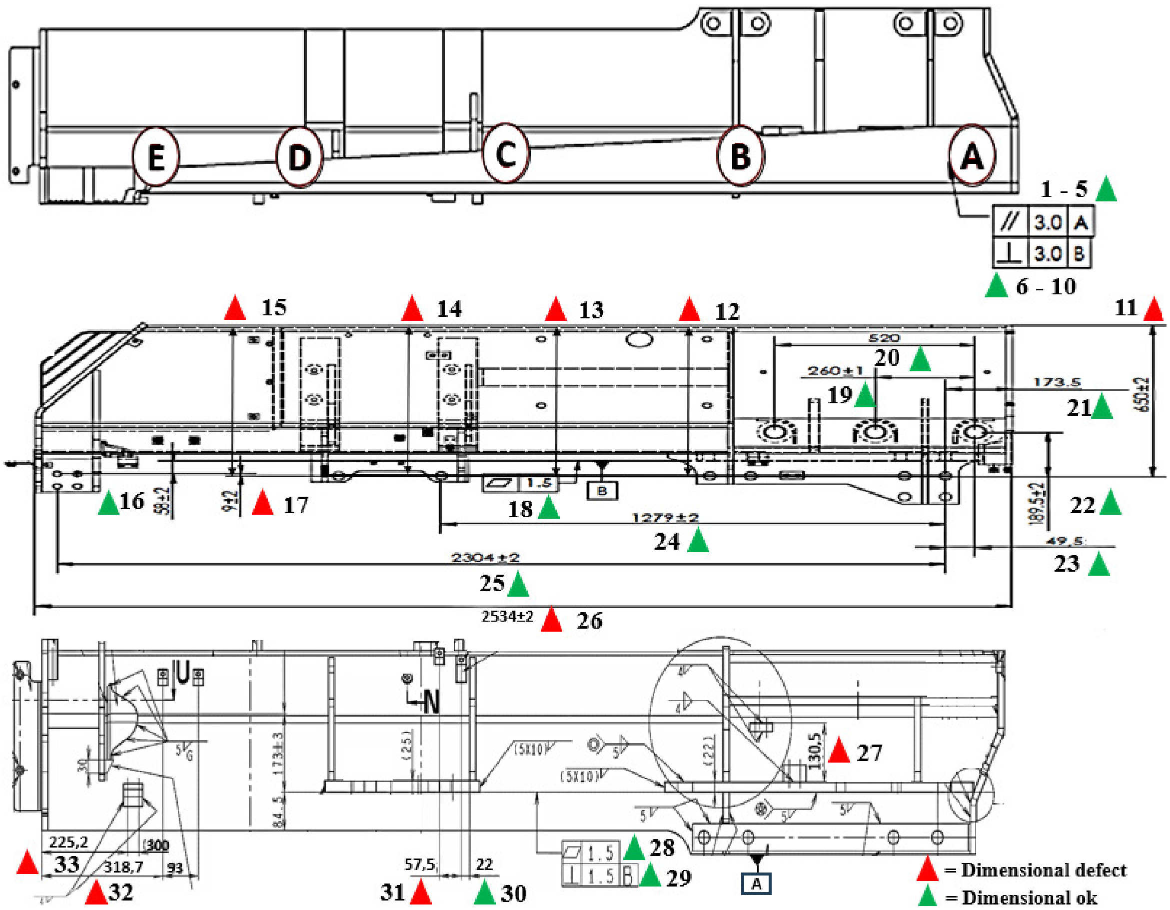

Figure 2. Dimensional defect points on the Fender D155A-6R.

The root causes of the defects were then analyzed using Komatsu Fault Tree Analysis (K-FTA) (Figure 3), a systematic method for identifying potential contributing factors to a failure or defect. By following the steps of the PDCA cycle, the manufacturing team can systematically identify opportunities for improvement, implement corrective actions, monitor results, and standardize proven practices, thereby driving continuous improvements in efficiency, quality, and productivity. This study focuses on identifying and reducing dimensional defects in the welding process of the Fender D155A-6R dozer component at PT. Arkha Jayanti Persada.

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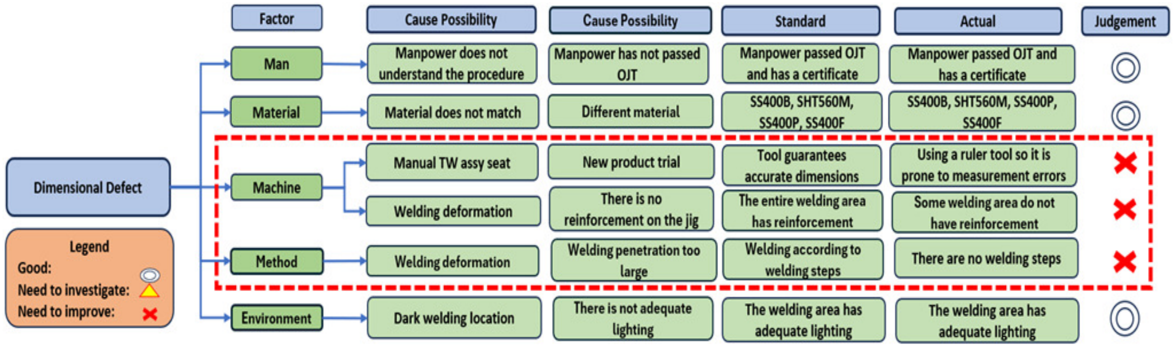

Figure 3. Komatsu fault tree analysis

The initial measurements of the Fender D155A-6R revealed dimensional deviations at several points that exceeded the specified tolerance limits. Measurements of parallelism, perpendicularity, and flatness do not have physical dimensions but have tolerances as limits of deviation. The detailed results of these initial measurements are presented in Table 1.

Table 1. Initial measurement results of all dimensions of the Fender D155A-6R before Kaizen.

Point	Dimension(mm)	Tolerance(mm)	Deviation(mm)	Geometric control
1	-	±3	2.1	Parallel to datum A
2	-	±3	2.5	Parallel to datum A
3	-	±3	2.6	Parallel to datum A
4	-	±3	2.4	Parallel to datum A
5	-	±3	2.1	Parallel to datum A
6	-	±3	2.7	Perpendicular to datum B
7	-	±3	2.5	Perpendicular to datum B
8	-	±3	2.4	Perpendicular to datum B
9	-	±3	2.6	Perpendicular to datum B
10	-	±3	2.3	Perpendicular to datum B
11	650	±2	-4.2	Lengthwise
12	650	±2	-4.9	Lengthwise
13	650	±2	-5.4	Lengthwise
14	650	±2	-5	Lengthwise
15	650	±2	-4.6	Lengthwise
16	58	±2	-1.7	Lengthwise
17	9	±2	-4.2	Lengthwise
18	-	±1.5	1.3	Flatness
19	260	±1	-0.4	Lengthwise
20	520	±1	-0.5	Lengthwise
21	173.5	±2	-0.9	Lengthwise
22	189.5	±2	-0.9	Lengthwise
23	49.5	±1	0.6	Lengthwise
24	1279	±2	-1	Lengthwise
25	2304	±2	-1.6	Lengthwise
26	2534	±2	-4.5	Lengthwise
27	318.7	±2	4.7	Lengthwise
28	-	±1.5	1.2	Flatness
29	-	±1.5	1.4	Perpendicular to datum B
30	22	±2	-0.6	Lengthwise
31	225.2	±1.2	4.2	Lengthwise
32	57.5	±1.2	4.1	Lengthwise
33	130.5	±1.2	4.6	Lengthwise

The Fender D155A-6R consists of 40 components made from various types of carbon steel and high-strength steel, namely SS400B, SS400P, SS400F, and SHT560M. SS400B and SS400P are low-carbon steels commonly used in construction and fabrication due to their good weldability and stable mechanical properties.

SS400F is a structural steel with higher tensile strength compared to SS400, making it suitable for applications requiring greater durability. SHT560M is a high-tensile strength steel designed for heavy-duty applications, offering excellent resistance to thermal deformation during the welding process.

The welding process in this study utilized two types of semi-automatic welding machines from the OTC brand. The first machine, the OTC Digital Dyna Auto XD500S, was used for welding thick plates with a 1.2 mm diameter welding wire. This machine has a current capacity of up to 500 A, enabling deep and stable penetration on high-strength steel. The second machine, the OTC XD350S, was used for welding medium- to thin-thickness plates, using a 0.8 mm diameter welding wire. This machine has a current capacity of up to 350 A. Both machines feature microcomputer-based digital control and employ the MAG (Metal Active Gas) welding method with pure CO_2 shielding gas.

The dimensional data collection process was carried out using a portable three-dimensional measuring instrument, the Faro Arm (see Figure 4). According to Samadi et al. (2025), the Faro Arm demonstrated reliable measurement performance, with a mean deviation of 0.0089 mm from the nominal values and a standard deviation of 0.0183 mm. These results confirm its capability as a precise dimensional inspection tool. First, in the data collection process, the operator moved the Faro Arm probe to touch the designated measurement points on the fender component to be analyzed. Each point touched was automatically recorded by the system and displayed in real time through software on the connected laptop. The coordinate data obtained from the measurements were then systematically documented in the inspection sheet for analysis and comparison with the specified dimensional standards. This process enables precise dimensional verification and serves as an essential part of the evaluation stage (Check) in the PDCA cycle during the implementation of Kaizen.

(a) (b) (c)

Figure 4. Measurement and data collection method: (a) Faro arm for dimensional measurement, (b) measuring the dimensions of the Fender D155A-6R using a Faro arm, (c) recording dimensional data displayed on a laptop.

3. RESULTS AND DISCUSSION

3.1 Kaizen with PDCA method

The main issue in the welding process of the D155A-6R fender was the inaccurate positioning of the seat, where operators still relied on simple measuring tools such as rulers, which led to frequent dimensional deviations. In addition, the absence of a reinforcement system to prevent deformation during welding often resulted in component distortions. The lack of a standardized welding sequence among operators further increased quality variations. Sumasto et al. (2023) showed that PDCA implementation effectively reduced defects in the automotive component industry, suggesting its potential to address welding defects in the Fender D155A-6R. To address this issue, improvements were carried out through two PDCA (Plan–Do–Check–Act) cycles. In the first cycle, the initial corrective actions did not fully deliver satisfactory results. Therefore, a second cycle was required to conduct further evaluation and refine the improvement measures. Through this dual-cycle approach, the improvement process could be implemented more effectively, ultimately achieving optimal results.

In PDCA 1, improvements included the creation of a locator tool, reinforcement of the fender's sides and sub-assembly, and the establishment of welding steps to minimize deformation. These actions reduced defects, yet slight deviations in the 650 mm dimension remained, necessitating PDCA 2. In the second cycle, additional reinforcement was applied to the fender's bottom and heat input was optimized in coordination with engineers, while the measures from PDCA 1 were maintained. The outcomes of PDCA 2 were then integrated into the working standard (Table 4) and welding procedure specification (Table 3).

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3.2 Taking form and implementing countermeasure

The improvement process in this study was structured through two PDCA (Plan–Do–Check–Act) cycles, which provided a systematic way to plan, implement, evaluate, and refine corrective actions. Among the measures applied, the development and use of a locator tool turned out to be the most influential. Before this tool was introduced, operators still relied on simple instruments such as rulers to align the seat. In practice, this often led to small inconsistencies that accumulated into dimensional deviations. With the locator tool, the seat could be positioned exactly according to the technical drawing (see Figure 5). This reduced the need for manual measurement and gave operators a clear reference point. During observations, the installation process appeared more consistent and faster compared to the earlier method. Errors caused by human judgment were largely avoided, and the dimensional accuracy of the assembly improved significantly. Interestingly, this finding is in line with Basuki (2023), who also reported the use of a locator tool within the PDCA framework in an automotive company. In his study, the tool helped lower the defect rate and even reached zero defects. Although the results in this research did not completely eliminate dimensional variation, they confirmed the same principle: simple but well-designed tools can play a crucial role in achieving continuous improvement in manufacturing.

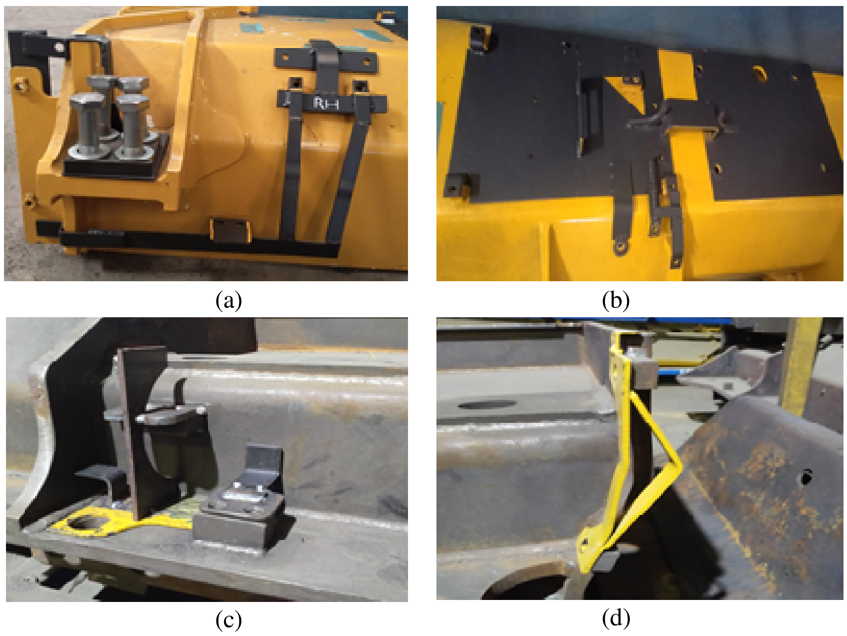

Figure 5. Locator tool.

Reinforcement was also added as part of this improvement (see Figure 6). This reinforcement serves as a support to prevent deformation caused by heat during the welding process. Welding deformation is a change in the shape of a material caused by uneven heating and cooling during the welding process. This deformation can lead to dimensional defects in the product after welding. This reinforcement works by holding the workpiece during welding, thereby reducing welding deformation and achieving a better final result. With this supporting structure in place, the component shape remains stable, thereby reducing the risk of distortion and maintaining dimensional conformity to the technical drawing specifications. This measure has proven effective in ensuring consistent welding quality for the Fender component.

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(a) (b) (c)

Figure 6. Reinforcement in deformation areas: (a) side section of the fender, (b) sub-assembly section of the fender, (c) bottom section of the fender.

In this improvement initiative, welding steps were introduced to serve as a systematic guideline for operators in determining the correct sequence and direction of welding. The establishment of such a procedure ensures greater consistency across operators, reduces the risk of heat-induced deformation, and helps maintain compliance with the required quality standards. The importance of welding step arrangements in minimizing deformation has also been emphasized in prior research. Ariani et al. (2024), for instance, demonstrated that a structured welding sequence can significantly reduce welding distortion and improve overall dimensional accuracy. Heat input adjustments, such as regulating amperage and voltage, were also carried out to control welding deformation. Guo et al. (2023) investigated TIG welding of thin bending plates, their findings confirm the general principle that higher heat input increases welding-induced deformation. This principle also applies to heavy-plate welding, where controlling heat input remains essential to minimize dimensional deviations.

3.3 Verification of results

After implementing the improvements, including the addition of a locator tool, reinforcement, welding steps, and heat input adjustments, the process then proceeded to the result verification stage. The improvement process through the implementation of Kaizen, carried out in two PDCA cycles, resulted in significant changes in the dimensional stability of the components. The measurement results for the 11 dimensional defect points are presented in Table 2, which contains information on the nominal dimensions, tolerance limits, deviations before the implementation of Kaizen, and deviations after the implementation of Kaizen in the second PDCA cycle.

Table 2. Dimensional deviations before and after Kaizen with two PDCA cycles at 11 dimensional defect points of the Fender D155A-6R.

Point	Dimension(mm)	Tolerance(mm)	Deviation before PDCA(mm)	Deviation After PDCA 2(mm)
11	650	±2	-4.2	-1.2
12	650	±2	-4.9	-1.4
13	650	±2	-5.4	-1.3
14	650	±2	-5	-1.1
15	650	±2	-4.6	-1.4
17	9	±2	-4.2	-1.2
26	2534	±2	-4.5	-1.4
27	318.7	±2	4.7	0.8
31	225.2	±1.2	4.2	0.6
32	57.5	±1.2	4.1	0.7
33	130.5	±1.2	4.6	0.9

The results presented in Table 2 show that all measurement points fall within the permissible tolerance limits. This outcome indicates that the application of the PDCA cycle was effective in minimizing dimensional deviations, particularly at points that had previously shown nonconformities. This also demonstrates that corrective actions such as the use of a locator tool, the installation of reinforcements, and the adjustment of welding procedures can reduce dimensional defects and improve production quality. The noticeable reduction in deviation highlights an improvement in production consistency as well as stronger compliance with established quality standards. In addition, the dimensional stability achieved after implementing Kaizen suggests that these corrective actions are not only effective but also sustainable, providing confidence that the improvements can be maintained in future production cycles.

To address dimensional deviation during welding, corrective actions were standardized into the revised Standard Operating Procedure (SOP), which includes tack welding, reinforcement installation, and dimensional inspection steps (Table 4). In addition, the updated Welding Procedure Specification (WPS) was formally documented to ensure welding parameters and essential variables are controlled and repeatable in production (Table 3). Together, these documents guarantee that both operational practices and welding parameters are consistently applied, thereby minimizing dimensional deviation

Table 3. Summary of Welding Procedure Specification (WPS No. WPS-FDR-D155A-01) for Fender D155A-6R.

Parameter	Specification
Welding process	GMAW (Gas Metal Arc Welding)
Filler metal	ER70S-6
Base metal	SS400B, SS400P, SS400F, SHT560M
Joint design	Combination of fillet welds and butt joints
Welding position	2F/3G (depending on component)
Wire diameter	1.2 mm (XD500S), 0.8 mm (XD350S)
Current (Ampere)	320 – 350 A (adjust by thickness)
Voltage	35 – 38 V (adjust by thickness)
Polarity	DCEP (Direct Current Electrode Positive)
Shielding gas and flow	100% CO_2, 15 – 20 L/min
Preheat and interpass temperature	50 – 100 °C
Sequence	(1) Tack welding, (2) Reinforcement instalation, (3) Full welding (zig-zag sequence to reduce distortion, (4) Seat and nut installation (using locator tool)
Inspection	Visual check each pass, dimensional check (Faro Arm)
Post-weld treatment	Grinding and cleaning

Building on the data in Table 2, the results were further illustrated in graphical form, as presented in Figure 7. The graph offers a clear visual depiction of the changes in dimensional deviation across 11 measurement points, both before and after the implementation of Kaizen through the PDCA cycle. The black line in the figure represents the conditions prior to improvement, showing that most of the measurement points initially lay outside the upper and lower tolerance limits (marked by the red dashed lines). This pattern confirms that the production process at that stage lacked the capability to maintain dimensional stability as required by the standards. After the corrective measures were introduced, the blue line in the figure illustrates the post-Kaizen results, where all points fell within tolerance, demonstrating the effectiveness of the improvements.

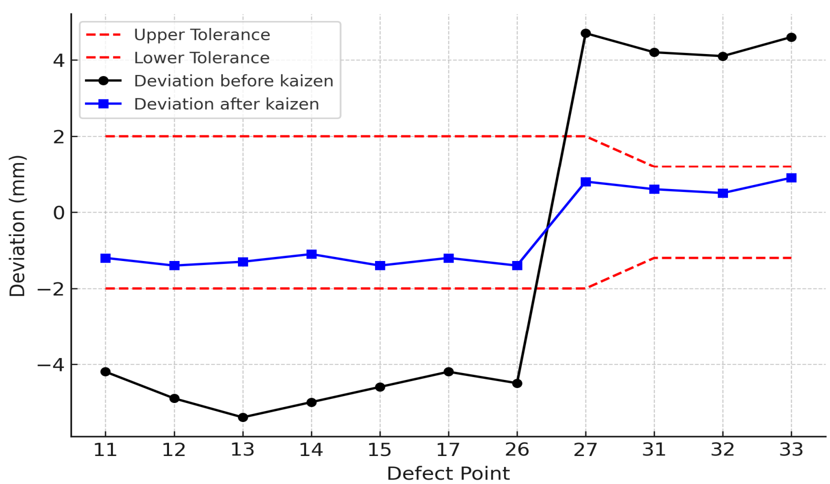

Figure 7. Changes in dimensional deviation at 11 measurement points before and after the implementation of the Kaizen approach with two PDCA cycles.

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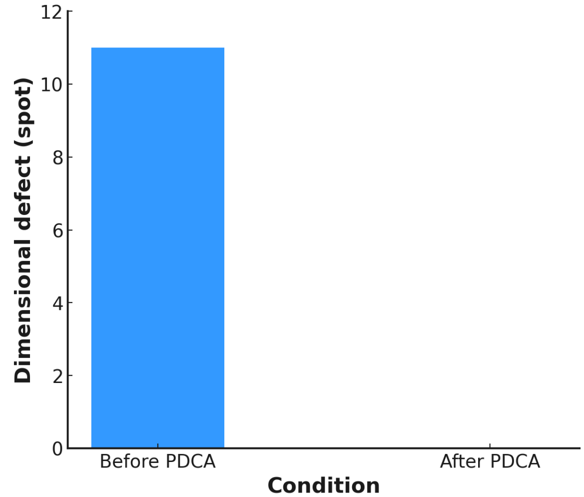

Figure 8. Changes in dimensional deviation at 11 points of dimensional defect before and after the implementation of Kaizen using the PDCA method.

After two cycles of the PDCA process, all dimensional defects were successfully eliminated (see Figure 8). This clearly demonstrates the effectiveness of PDCA-based kaizen in addressing the problems encountered. The findings of this study provide strong evidence that the improvements implemented were in line with the expected outcomes. Similar results were reported by Nugrowibowo and Rosyidi (2023), who showed that the application of PDCA approach was able to eliminate defects in aluminum alloy wheel production processes and reduce defect from 12.89% to 6.61%. Likewise, Pranata et al. (2024) found that defects in barrel components were successfully reduced using the PDCA-based kaizen method. In another study, Singh and Gandhi (2023) emphasized that the PDCA cycle was effective in lowering rejection rates to zero in medium-scale manufacturing industries. Overall, these findings are consistent with the results of the present study, confirming that PDCA-based kaizen supports continuous improvement and helps maintain overall product quality.

3.4 Standarization

The improvements were subsequently standardized through the development of a standard operating procedure document (Table 4), which encompasses all corrective measures implemented. In the study by Juhaeti (2024) on the effect of standard operating procedures on product quality, it was found that standard operating procedures improve product quality by up to 25.1%. Therefore, to maintain product quality, it is necessary to establish standard operating procedures. This standard was communicated to operators through training and briefings to ensure process uniformity on the shop floor. The objective was to maintain consistent quality and prevent the recurrence of dimensional defects.

Table 4. New Standard Operating Procedure (SOP) for Fender D155A-6R welding process

Step	Process description	Purpose	Control method
1	Tack weld main plates	Temporary fixation before full weld	Ensure alignment, prevent shifting
2	Install reinforcement	Reduce deformation during welding	Reinforcement applied in side, sub assy and bottom Fender
3	Full weld (Zig – zag sequence)	Permanent joining of components	Follow WPS parameters (Ampere, voltage, travel speed)
4	Dimensional inspection I	Verify dimensions after full weld	Measurement using Faro Arm (3D coordinate measuring tool)
5	Seat and nut installation (with locator tool)	Ensure accurate positioning	Locator tool prevents misalignment
6	Dimensional inspection II	Final verification of dimensional accuracy	Re-measurement with Faro Arm to confirm tolerance compliance
7	Grinding and finishing	Improve surface quality, remove spatter	Grinder and finishing tool

4. CONCLUSION

Based on the findings, the implementation of Kaizen using the Plan–Do–Check–Act (PDCA) method in the welding process of the Dozer D155A-6R fender components proved effective in eliminating dimensional defects. Initially, 11 points of dimensional defect were identified, primarily caused by the absence of a locator tool, the lack of reinforcement to prevent deformation, and the absence of a standardized welding procedure (welding step). Through improvements involving the locator tools, the installation of reinforcement, and the establishment of a systematic welding step, all defect points were successfully eliminated, achieving zero defect. These results demonstrate that Kaizen implementation can sustainably improve product quality and serve as a strategic reference for quality control in future production processes.

ACKNOWLEDGMENTS

The author would like to express sincere gratitude to PT. Komatsu Indonesia for the internship opportunity provided through the MBKM program, as well as to PT. Arkha Jayanti Persada for their full support during the internship activities, particularly in providing data, facilities, and technical guidance in the field. Appreciation is also extended to the Department of Mechanical Engineering, University of Mataram, for the academic and administrative support provided. The author further wishes to thank the academic supervisor and all parties who have assisted and contributed to the preparation of this report and the writing of this journal.

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