Reducing an Indonesian Auto Part Production Cycle Time using the PDCA Approach: A Case Study

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ABSTRACT

Constituting the biggest challenge in any manufacturing company's product delivery, operational excellence can be accomplished by obtaining the best Quality, Cost, and Delivery (QCD). The delivery parameter has been an issue for the ABC Company, an Indonesian auto part manufacturer, having automotive manufacturers as customers, since its cycle time has been found to be lower than its takt time. This could jeopardize the company's status in that it could degrade its customer service level. Thus, the company immediately initiated a quality control circle, especially when it was revealed that its production cycle time in Core Assy Line 3 was 49 s more than its targeted 41.7 s takt time. The team was then committed to reducing it to 39.2 s, accounting for a 20% reduction. A method named 8 steps and 7 tools was deployed under the Plan-Do-Check-Act (PDCA) approach to solve the specific problem. This method guided the team to find five root causes of the problem, while five solutions were equivalently provided. As a result, the achieved cycle time reduction was from 49 to 38.9 s, that is, a 21% decrease, capable of securing the company's relationship with its customers and granting an order increase.

Keywords-quality control circle; PDCA; 8 steps and 7 tools; cycle time; takt time

I. INTRODUCTION

Achieving operational excellence by obtaining the best QCD has always been a paramount subject of concern for any manufacturing company in order for the latter to stay competitive in the market. It usually involves the quality control circle method, which has been widely employed across several industries and sectors, especially due to its competence in achieving the best QCD of various products and services. For this reason, the ABC Company decided to adopt it for its improvement initiative, which was a priority owing to the fierce market competition. As one of the auto part manufacturers in Indonesia, the specific company should be able to fulfill its customers' orders so as not to disturb the automotive supply chain in the country. However, it faced a challenge regarding its production cycle time, which was 49 s higher than its targeted 41.7 s takt time due to an increase in customer orders. Thus, a quality control circle was formed to tackle this problem by using the 8 steps and 7 tools method under the PDCA approach. The current paper aims to explain how this method addresses and resolves the issue of the production cycle time using the circle approach. Its contribution is that it demonstrates how the 8 steps and 7 tools method can be utilized to tackle the aforementioned issue instead of the PDCA approach that has been widely employed in this field. According to [1], finding improvement opportunities to enhance business performance has been the main goal of every manufacturer. Many of them tend to employ the PDCA cycle methodology using seven quality control tools [2]. Meanwhile, for the same purpose, an alternative method, the 8 steps and 7 tools, can be deployed. The process covers steps such as:

1. Defining the problem.
2. Setting the target.
3. Analyzing the root cause.
4. Planning improvement.
5. Implementing the plan.
6. Evaluating the result.
7. Standardizing the process.
8. Planning the next theme.

During these steps' implementation, seven tools that are popular in the quality management field are deployed to meet the company's objectives [3]. These tools are widely adopted across multiple industries and fields [4] owing to the straightforward statistical techniques they utilize, making them effective problem-solving tools [5, 6], with almost 95% of the quality problems being solved by using them [4, 7]. The former include check sheets, Pareto diagrams, histograms, cause and effect diagrams, fishbone diagrams, scatter diagrams, and control charts [8], and can be also utilized to improve quality [9, 10]. The previously discussed steps and tools are integrated, forming the 8 steps and 7 tools method, deployed under the four phases of the PDCA cycle, and are known as the QC Story [11].

II. METHOD

The 8 steps and 7 tools method followed for the discussed cycle time reduction is illustrated in Figure 1.

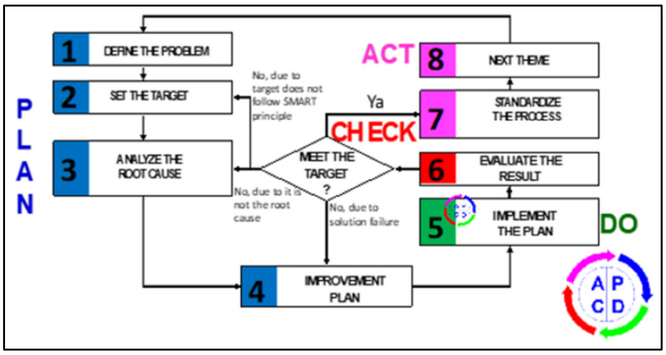

Fig. 1. 8 steps and 7 tools method for process improvement.

Figure 1 shows how the 8 steps and 7 tools can be utilized, being depicted as a systematic method in which every step should be accomplished before the next step is initiated. On top of that, these steps detail the PDCA cycle to better guide the company team to reach their goal. The steps and tools are as follows:

1. Defining the problem using a check sheet, stratification, and Pareto diagram.
2. Setting the target using a histogram.
3. Analyzing the root cause using fishbone and scatter diagrams.
4. Setting an improvement plan.
5. Implementing the plan.
6. Evaluating the result compared to the target.
7. Standardizing the process.
8. Setting the next theme as described in [12].

III. RESULT

1) Defining the Problem

In this step, the quality control circle examined the rise in orders across the company's production lines. As indicated in Table I, four lines are experiencing an increase in customer orders.

According to Table I, the Core Assy Line 3 experienced the highest order increase percentage, which is confirmed through the Pareto diagram displayed in Figure 2.

TABLE I. ORDER INCREASE

Line	%Order Increase	Percentage	Accumulative
Core Assy L#3	40.2%	38.8%	38.8%
Core Assy L#2	22.7%	21.9%	60.7%
Core Assy L#5	21.3%	20,6%	81.3%
Core Assy L#4	19.4%	18.7%	100%
Total	103.6%	…	

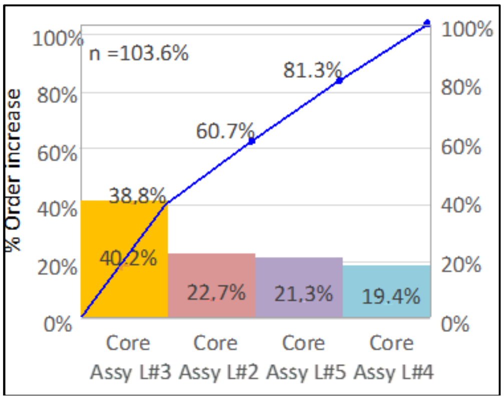

Fig. 2. Pareto of order increase.

The Pareto diagram, evidenced in Figure 2, confirms that further investigation of the Core Assy Line 3 should be prioritized, to check whether its cycle time is still or the same as its takt time. Thus, the quality control circle calculated its takt time to compare it with its cycle time, as shown in Figure 3. It is observed that the cycle time of the Core Assy Line 3 was 49 s, exceeding its 41.7 s takt time. This discrepancy became the primary issue for the quality control circle to address, with reducing the cycle time being identified as the team's key problem theme.

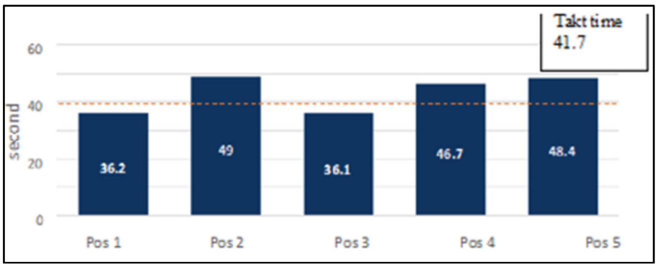

Fig. 3. Cycle Time versus Takt time.

2) Set the Target

The quality control circle subsequently proceeded with setting the target, which can be seen in Figure 4.

3) Analyze the Root Cause

In the previous step, it was identified that the initial cycle time did not meet the required takt time. Consequently, the circle needed to analyze the root cause of the particular issue using a fishbone diagram, as illustrated in Figure 5.

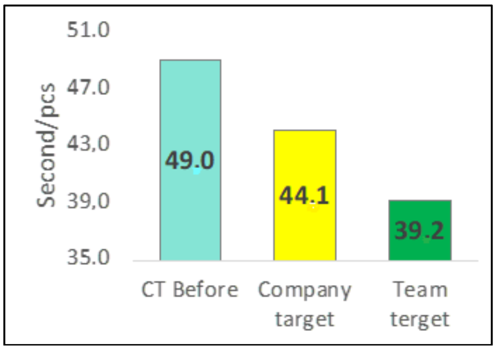

Fig. 4. Target setting.

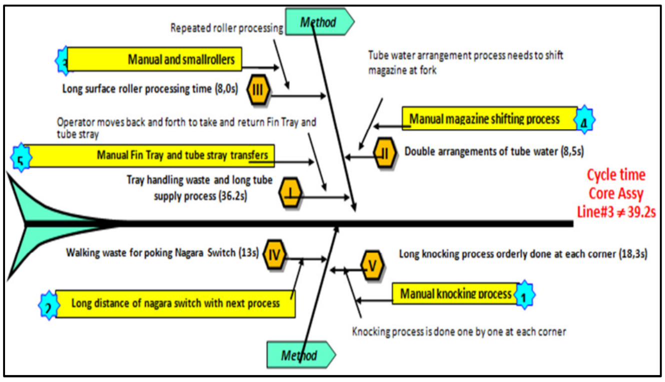

Fig. 5. Fishbone diagram.

Figure 5 depicts the five root problem causes having emerged in the process. These are:

1. The manual knocking process in Post 5.
2. The long distance of the nagara switches from the next process in Post 4.
3. The manual and small rollers in Post 4.
4. The manual magazine shifting process in Post 2.
5. The manual fin tray and tube stray transfers in Post 1.

4) Improvement Plan

This step includes an improvement plan proposed by the quality control circle to tackle the root causes found in the previous step. The plan covers:

1. Automating the knocking process by combining it with the machining process in Post 5.
2. Auto machine running and utilizing a cylinder sensor for the PLC input in Post 4.
3. Employing an auto-rolling robot with a wider cross-section and transferring the rolling process from Post 3 to Post 4.
4. Installing a robot to shift the magazine tube automatically in a one-time process in Post 2.
5. Installing a robotic auto-transfer fin and an automated supply system integrated with the fin-forming and tube-arranging process in Post 1.

5) Implementing the Plan

This step is dedicated to executing the plan that has been made and approved for implementation. The following section describes the five solutions in detail.

a) S1. Automating the Knocking Process by Combining it with the Machining Process in Post 5

This plan enables operators to integrate the compressing process with the knocking process, achieving a higher level of automation without introducing defects, as portrayed in Figure 6. By implementing this plan, the cycle time can be reduced from the target time of 20.9 s to 18.3 s.

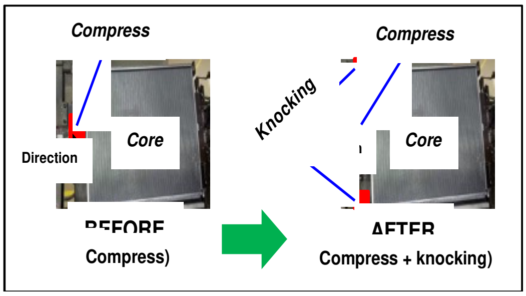

Fig. 6. Solution 1.

b) S2. Auto Machine Running and Utilizing a Cylinder Sensor for PLC Input in Post 4

Automated machine operation was achieved by employing a sensor-equipped cylinder, eliminating the need for human intervention, as shown in Figure 7. After implementation, the cycle time was reduced from the target time of 30.1 s to 27.5 s.

Fig. 7. Solution 2.

c) S3. Employing an Auto-Rolling Robot with a Wider Cross-Section and Transferring the Rolling Process from Post 3 to Post 4

Figure 8 shows the difference in the before and after states. Before this solution was provided, the operator had been manually executing the rolling process. With this solution, an auto-rolling robot replaced human intervention in the specific process, reducing the process time from 28 to 16 s.

a) S4. Installng a Robot to Shift the Magazine Tube Automatically in an One-Time Process in Post 2

Shifting tube magazines that were handled twice were replaced by a robot that was automatically handled once. The time reduction achieved was from 33.7s to 21 s.

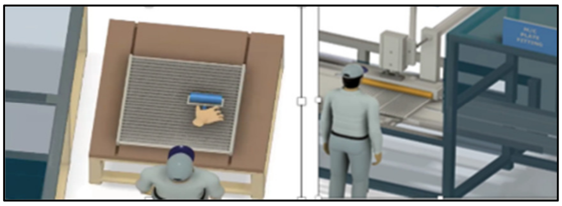

Fig. 8. Solution 3.

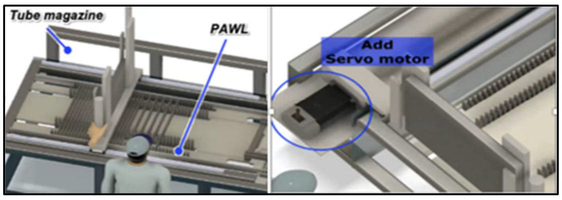

Fig. 9. Solution 4.

b) S5. Installing a Robotic Auto-Transfer Fin and an Automated Supply System Integrated with the Fin-Forming and Tube-Arranging Process in Post 1

The robot auto-transfer fin and auto supply tube, as shown in figure 10, are replacing human intervention, so the process is done automatically, eliminating time to 36.2 s in this post.

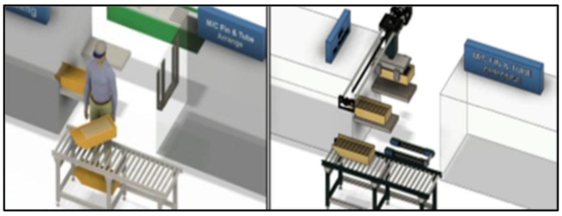

Fig. 10. Solution 5.

6) *Result Evaluation*

After the solutions are implemented, the quality control circle derives the evaluation results to find out if they reached their target, as displayed in Figure 10.

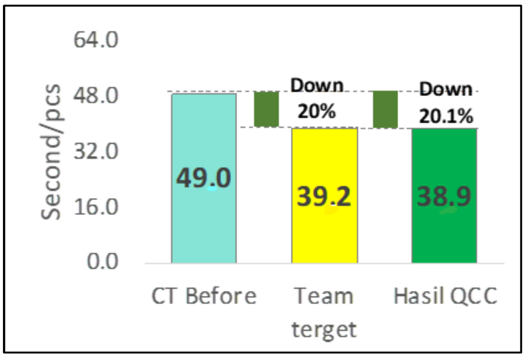

Fig. 11. Evaluation.

Figure 11 demonstrates that this project successfully reduced the cycle time from 49s to 38s, which is 0.1% more than the 20% reduction targeted by the team.

7) *Standardize the Process*

Due to its success, the quality control circle conducted the process of standardization, as evidenced in Table II.

TABLE II. STANDARDIZATION

No	Problem	Improvement
1	Manual knocking process	Knocking process automation
2	The machine uses a nagara switch to start the process	Sequence modification program (machining plate fitting)
3	Manual roller process	Core rolling process automation
4	The tube water arrangement process is still manual	Tube arrangement process automation
5	The fin and supply tube transfer process is still manual	Fin and supply tube transfer process automation

8) *Next Theme*

In this step, the quality control circle proposed the next theme, as depicted in Figure 11.

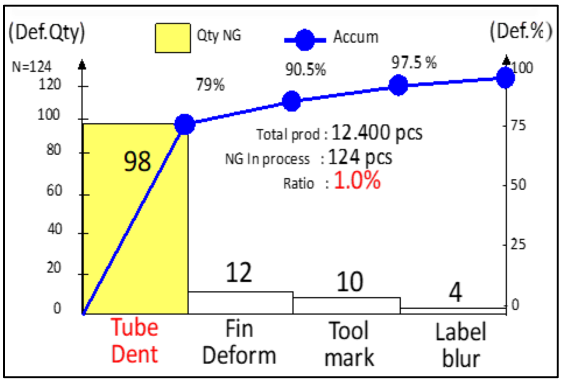

Fig. 12. Pareto Diagram.

Figure 12 indicates that as a type of defect, tube dents should be prioritized as the next theme for the quality control circle. This will be also handled by the 7 QC tools, as implemented by the proposed method or other methodologies, such as the DMAIC [13, 14].

IV. CONCLUSIONS

The method proposed in the current paper has managed to reduce the cycle time of the ABC Company from 49 to 38.9 s, achieving a 21% reduction, which is below its 41.7 s takt time. Thus, the Company can secure customer order increases without disturbing the automotive supply chain in the Indonesian nation. Several conclusions can be drawn from this research. First, the decision to initiate a quality control circle to improve its cycle time was precise because it was found that this problem can be successfully solved. Moreover, the quality control circle detected five causes of the problem and, respectively, provided five solutions to them. However, through the quality control circle the limitation of this project was also discovered, which is related to product quality. Thus, future research is needed to cover the quality aspect of the project.

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