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Reducing Waste in The Production of Agricultural Machinery Parts: Case Study Manufacturing Process of Collar A Tractor Parts

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Abstract

This study aims to reduce the waste surplus (defects) in the production process of agricultural machinery parts in the production process of Collar A tractor parts by using the Pareto chart to find significant problems. After that, the root cause of the problem is analyzed using a fishbone diagram, and why-why analysis leads to the root cause utilizing ECRS principles for correction to help improve processes. Based on current research, defect data from the past three months was collected. The main problem is that with a diameter of 40.5 over spec, the average defect proportion is 53%. Therefore, after ECRS improvement using the R: Rearrange principle, modify the workflow, to eliminate the loss that occurs in the production process, resulting in the proportion of waste reduced to only 1 percent.

Keywords
Agricultural machinery, Pareto chart, ECRS, Fishbone diagram, Rearrange principle.

1. Introduction
The rapid growth of the agricultural machinery market is partly expanding due to new generations working in Bangkok migrating to their hometowns because of the outbreak of the COVID-19 pandemic. Some people investigate the savings earned in Bangkok on agricultural machinery for workforce reduction and efficiency improvement on the family property. Moreover, due to the considerable growth of the agricultural machinery parts manufacturing industries, inevitable competition occurs in the business contributing more comparative options to the customers. Consequently, the entrepreneurs primarily concentrate on manufacturing cost control to improve defect reduction and productivity enhancement efficiency.

The case study was an automotive parts manufacturing company for various automakers, including agricultural parts. However, as a recent problem, a waste surplus with a diameter of 40.5 over spec was generated in the manufacturing process of Collar A tractor parts. Furthermore, the data collection over the past three months indicated that the average monthly defect proportion was 53%. A defect problem, therefore, was analyzed by applying the fishbone diagram, and methods for waste reduction were further determined respectively.

1.1 Objectives
- To reduce waste in the manufacturing process of Collar A tractor parts.
- To improve the manufacturing process of Collar A tractor parts.

2. Literature Review

The ECRS Principle consists of Eliminate, Combine, Rearrange, and Simplify, a simple method used in the production process to increase efficiency and effectively reduce waste. Numerous studies applied the ECRS principles to improve efficiency and minimize waste in the production process. Moreover, it was also widely applied in many studies to combine with other principles for better efficiency improvement. For example, the study about the line balance of work stations and waste reduction in the production process aimed to improve the process of production by initially defining the standard time of each work station and then analyzing man and machine working relationship using the Man-Machine Chart. After that, apply the ECRS Principles for an improvement of the production lines (Sornsiri R. 2017), Improve the working method and reduce idle time generated in the production process with the Kaizen Concept application to diminish looses and non-value added activities, and analyze the root causes of the problem through the Why-Why Analysis then improve working procedures by the ECRS principles implementation (Amornrut P. and Siraphong L. 2020), Minimize the proportion of waste by applying the Pareto Chart analysis consequently, determine the cause of each waste type by using the fishbone diagram and evaluate the causes required to be improved (Thanatchadit S. and Patipan M. 2019), Decrease the wastes incurred in an automobile tire manufacturing applying Lean Manufacturing System, Work Study, Value Stream Mapping (VSM), and Flow Process Chart. The ECRS Principle is then introduced to improve the working methods by utilizing the 5W1H questioning approach, which considers the combinable, unnecessary, and eliminable works. (Jirakan and Jirapat 2021), Reduce defects in an incompletely joined pickup truck front-double wishbone manufacturing process. The Pareto chart is exploited to prioritize the nature of problems then the fishbone diagram analyzes the wastes. Therefore, the S: Simplify, or working performance simplification, in the ECRS principle, is utilized to improve the process of workpiece removal from the clamping devices (Paitoon et al. 2020).

3. Methods

This research method studies the production process of agricultural machinery parts in the Collar A tractor parts manufacturing process to identify problems and analyze data using the Pareto chart to discover the proportion of waste. After that, a fishbone diagram is applied for the root cause analysis. Additionally, a Why-Why analysis leads to the root cause and resolution with the ECRS principles implementation to help the process improvement by collecting defect data for the past three months, as shown in Table 1, comparing the percentage of defects to hardened workpieces, for which a minimum hardening quantity is 500 pieces.

Table 1. The defects with a diameter of 40.5 over spec from June to August 2022

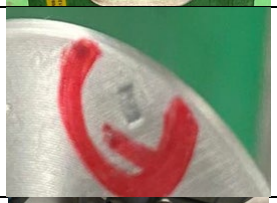
Month	Hardening (pieces)	Standard (pieces)	Defect (pieces)	% Of Defect
June	1,199	618	581	48%
July	1,317	587	730	55%
August	1,514	667	847	56%

3.1 Manufacturing processes study and primary production data collection

Figure 1. Collar A Manufacturing processes

The researcher collects incurred defect characteristics, as shown in Table 2.

Table 2. Defect characteristics.

Defect appearance picture	Defect appearance
	Diameter of 40.5 over spec.
	Scratches.
	Length of 7 lower spec.
	Diameter of 32 over spec.

3.2 Production line defects analysis by utilizing the Pareto Chart

Conduct the Pareto Chart in Figure 2 to identify wastes that account for 80 percent of the total. Then analyze it to determine the main cause of most waste in the production lines in the following step.

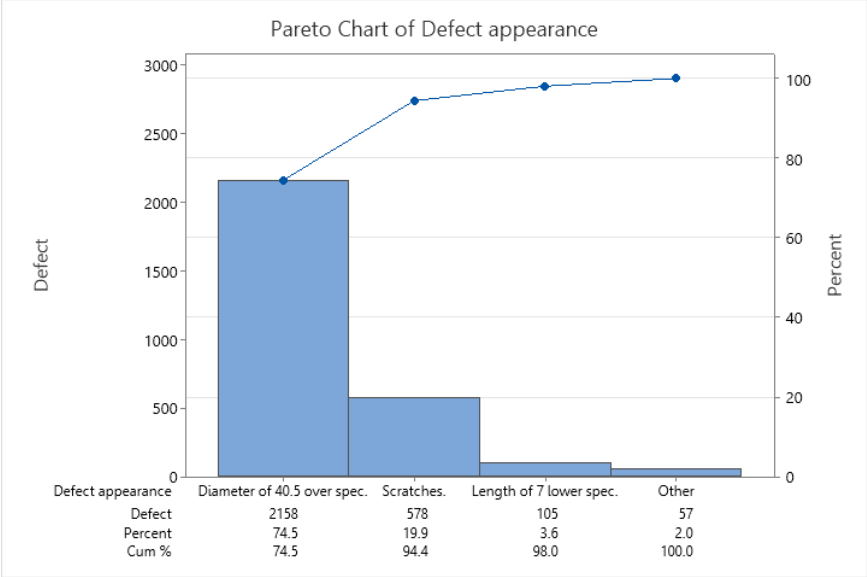


Figure 2 Pareto Chart shows the defect appearance.

From the Pareto Chart, the 80-20 Rule, which states that 80 percent of the results are derived from 20 percent of the causes, is applied; hence, the primary waste characteristic that requires correction is the Defect with a diameter of 40.5 over spec as to find causes for the further improvement.

3.3 Cause of primary waste identification and Cause and Effect Diagram Systematic Creation

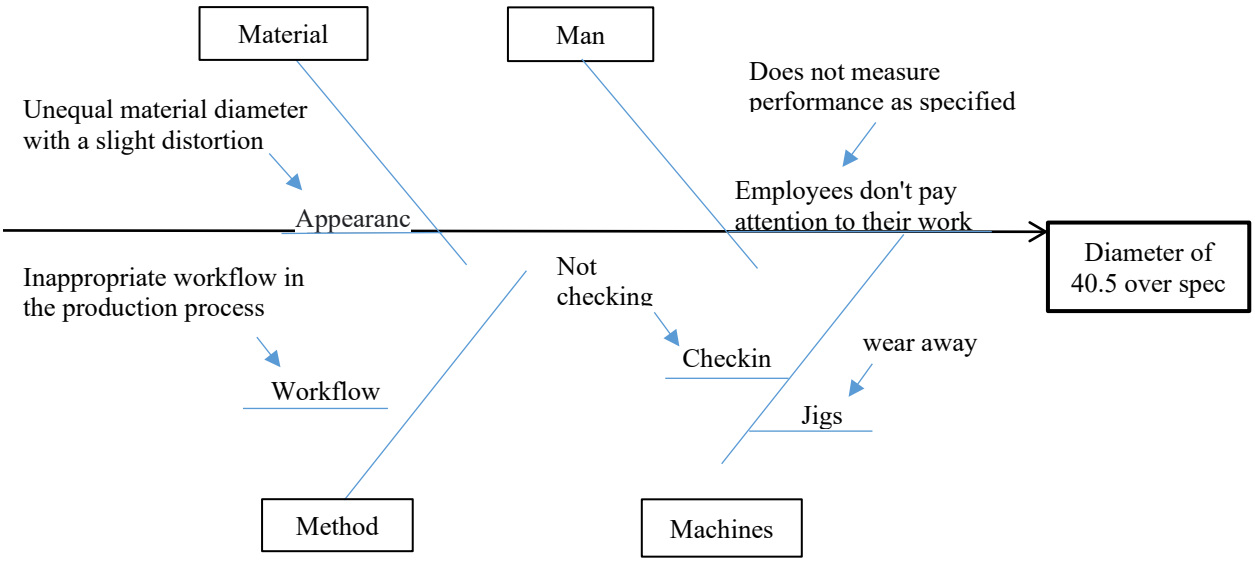


Figure 3. The fishbone diagram of defects with a diameter of 40.5 over spec

From the figure3 to discover the potential causes that influence the Defect with a diameter of 40.5 over spec, the fishbone diagram is considered by applying the 4M method: Man, Machine, Materials, and Method are as follows:

Man

• Due to a lack of motivation and fatigue from working, operators pay less attention to the measurement of the workpieces at a specific time

Method

• Inappropriate workflow in the production process

Machine

• Dilapidated clamps due to a numerous use

Material

• Unequal material diameter with a slight distortion

In order to obtain the root cause of the problem, Why Why analysis is applied as an analysis method for the problem with a diameter of 40.5 over spec by questioning "Why-Why" based on relevant factors and characteristics in the work process. In this case, the cause of analysis has been divided into three categories: man, method, and machine. Nevertheless, unequal material is not considered a cause of the problem, for it has been examined before the production process; thus, it has not been analyzed, as shown in Figure 4.

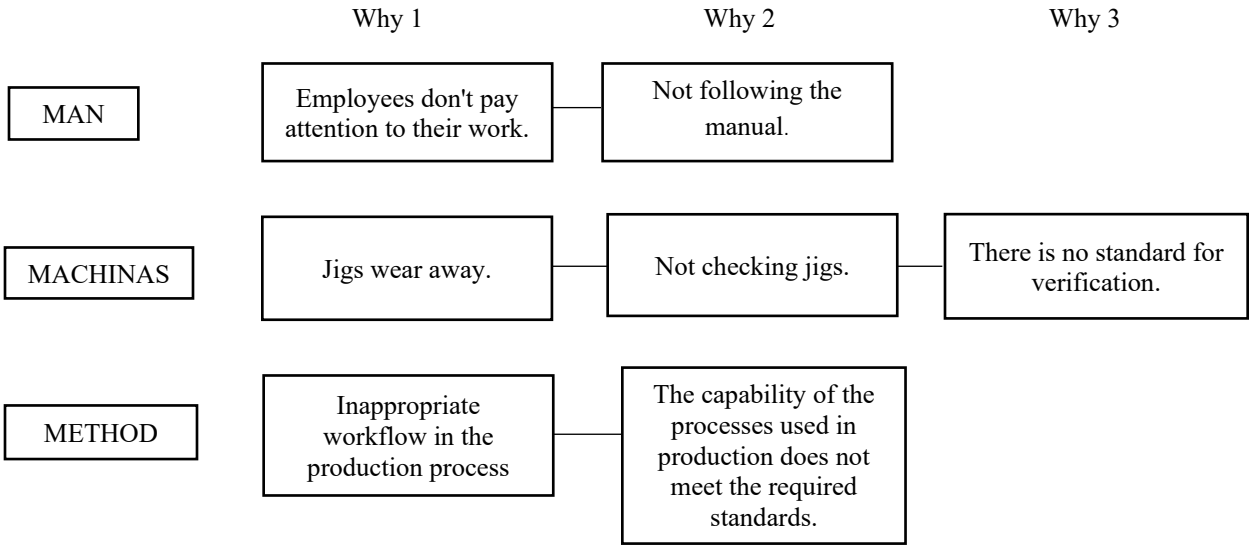


Figure 4. Root cause analysis with Why-Why Analysis application

3.4 Problem-Solving Analysis

The cause of the problem illustrated in the Cause and Effect Diagram could be concluded that the main problem with a diameter of 40.5 over spec is a result of three causes: man, machine, and method; therefore, the production method is selected for resolving since it is the main reason resulting in a large number of defects.

3.5 The ECRS Principle implementation for the process improvement

According to the root causes analysis of the production method, it is evident that the production workflow is unsuitable, causing numerous defects in the Collar A tractor production process. The ECRS principle is, therefore, utilized for process improvement with the R: Rearrange principle, which means moving, switching, or modifying the workflow by changing the production workflow.

4. Results

The ECRS principle is utilized for production improvement by changing the production workflow by switching steps three and step 4, which are as follows: Step 2 (Lathe 1), Step 3 (Broaching), and Step 4 (Lathe 2), as shown in Figure 5

Figure 5. The Collar A manufacturing process after a modification

The data was consistently collected for three months, from October to December 2022. After the workflow improvement, it was found that the number of defects with a diameter of 40.5 over spec had decreased, as illustrated in Figure 5

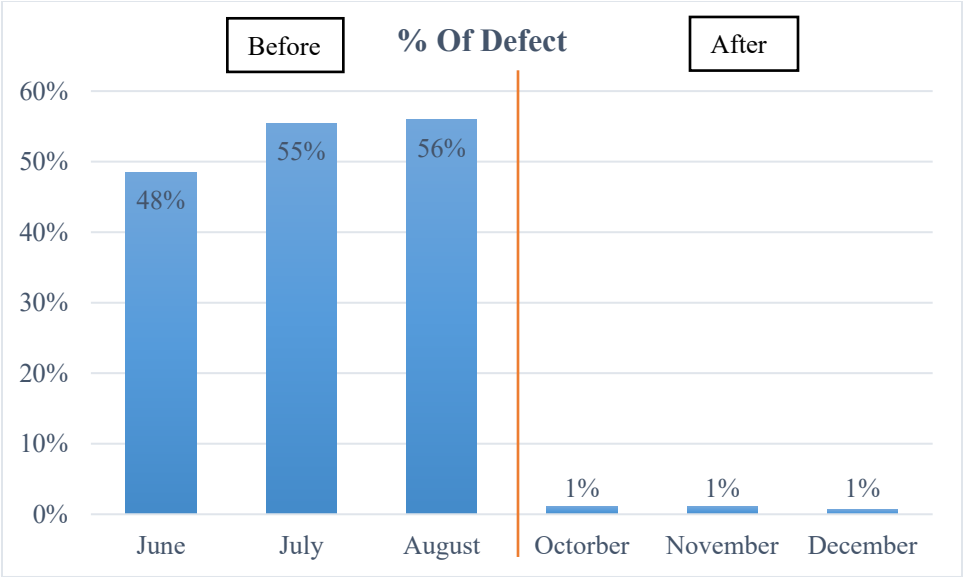


Figure 6. Comparison of the percentage of defects before and after modifying the workflow

Figure 6 shows that from 2022 June to August, before the workflow modification, the average waste proportion with a diameter of 40.5 over spec was 53%; however, it significantly decreased to merely 1% from 2022 October to December after modifying the workflow.

5. Conclusion

After the improvement to remove the waste surplus with a diameter of 40.5 over spec in the agricultural machinery parts production process in the Collar A tractor manufacturing process, it was found that the waste proportion dramatically dropped from 53% to only 1% per month. Consequently, the production processes of the Collar A tractor parts remarkably raised production efficiency and decreased defects of the case study company.

References

Sornsiri Ruanglok, Efficiency improvement of small earth leak breaker. Department of Industrial Development, Faculty of Engineering, Thammasat University, 2017

Amornrat Pinchaimoon, Sirapong Lueachai, Kaizen Concept for Improvement Work Method in Rice Cracker Process Department of Engineering and Technology, Rajamangala University of Technology Lanna Chiangrai, 2020

Thanachdit Saensingchai, Patipan Matha, Defect Reduction of Machinery Parts Manufacturing. Department of Industrial Engineering, Faculty of Engineering, Chiang Mai University, 2019

Jirakan Kanlayapo, Jeerapat Ngaoprasertwong, Waste Reduction in Tire Flap Manufacturing Process. Department of Industrial Engineering, Faculty of Engineering, Chulalongkorn University, 2021

Phaitoon Sirioraron, Wiroj Thantipatro, Amornthep Dokmai, Defection Reduction In Manufacturing Process Of Front Double Wishbone Of A Pickup Truck. Faculty of Engineering and Technology, Panyapiwat Institute of Management, 2020

Biographies

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