Defect Reduction Strategies for Can Cap Stamping Process

Somporn Phromduang*, Saisunee Pongpatanasuegsa, and Phakphong kaennarong

The Industrial Engineering field, College of Engineering, Rangsit University, Pathum Thani, Thailand
*Corresponding author, E-mail: Somporn.p@rsu.ac.th

Abstract

This study aimed to reduce waste in the can lid production process of a sample company that produces stamped can lids, which have faced production issues due to defective products or quality that does not meet customer requirements. The primary problem in the company was scratched can lid defects, accounting for 40.73% of total waste (75,218 pieces), significantly impacting production costs. The research utilized statistical process control techniques and Minitab version 14.0 software package for production process control, along with quality control tools for problem analysis and cost comparison before and after improvements. The results showed a reduction in scratched product issues on workpieces after improvements, with waste decreasing to 15,122 pieces, representing 12.14% of the total waste. This reduction amounted to a 28.59% decrease in scratched waste before improvement in the can lid stamping process, equivalent to 132,063.03 Baht for the 7-month production period or 222,399 Baht per year.

Keywords: *Waste, Production, Can Lids*

1. Introduction

The can industry specializes in producing can lids as packaging for various sectors, such as the canned food industry (including canned fish and fruit), paint, and chemical packaging. Lately, the can lid production industry has experienced rapid growth, becoming highly competitive in terms of both product quantity and quality. As a result, entrepreneurs must develop effective strategies to compete in the market by providing high-quality products that meet customer needs and enhance value-added performance.

The stamping process is an essential step in the production of can lids, transforming raw materials into the final product that securely seals cans. This process involves a series of stages, each playing a vital role in creating high-quality lids (Figure1).

1) Material selection: The raw material, typically aluminum or tinplate, is chosen based on factors such as cost, weight, corrosion resistance, and compatibility with the contents of the can.

2) Sheet cutting: The raw material is supplied in large sheets, which are cut into smaller, more manageable pieces according to the required dimensions for the can lids.

3) Stamping: The core of the process, stamping involves a high-pressure stamping machine that utilizes dies to shape the cut material into the desired lid profile. This process can include multiple stages, such as blanking, drawing, and forming, to achieve the precise contours and dimensions of the final lid.

4) Edge rolling: Once the lids are stamped, their edges are rolled to create a smooth, even surface that will form an airtight seal when attached to the can body.

5) Compound injection: A plastic or rubber compound is injected into the inner rim of the lid to enhance the seal and prevent air or contaminants from entering the can. This step is crucial to maintain the freshness and quality of the can's contents.

6) Quality control: Throughout the production process, quality checks are performed to identify and remove defective lids. This may involve visual inspections, dimensional checks, and testing the integrity of the seal.

7) Packaging and storage: Once the lids have passed all quality control measures, they are packaged and labeled for smooth customs clearance and accurate tracking of shipments.

8) Keeping in Store: The products have been stored in a warehouse and ready to be shipped to customers.

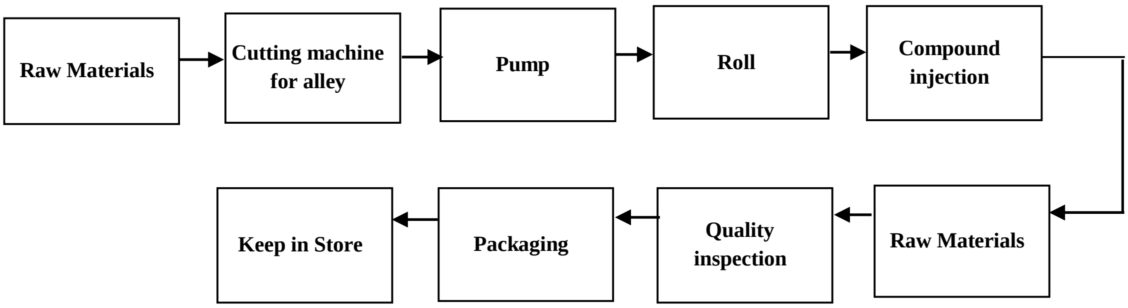

Figure 1 The process of stamping can lid

By closely monitoring and optimizing each stage of the stamping process, can lid manufacturers can produce high-quality products that meet customer expectations and industry standards. This, in turn, contributes to the overall success and profitability of the company. This research examined a company in the can lid industry that produces lids through a stamping process, primarily using aluminum as the raw material. The production process begins with cutting aluminum sheets to the desired size, followed by feeding the cut sheets into a slitting machine. The machine then stamps the lids using a cap pumping process, rolls the edges, injects a plastic compound to create an airtight seal, and dries the lids. Finally, the lids are quality-checked, packaged, and stored in a warehouse. As any defects or nonconformities in the lids will directly impact on the products delivered to customers, therefore it is defined to be the waste products of the production line.

Figure 2 shows the can lid products produced by the study company. There are four sizes with metallic coated and gold coated. The number of waste products were counted without size classification in the production.

Figure 2 Various can lid sizes from the production of the study company

This waste can be classified into five distinct categories: scratches, incomplete rubber seals, wrinkled lids, dents, and discolored lids. Figure 3 showed the example a stretches (Figure 3a) found in a waste produced from the stamping process and a wrinkle found at the hand pulling (Figure 3b).

Figure 3 Waste from the process of stamping can lids

In a highly competitive industry, even minor discrepancies in quality can impact customer satisfaction, damage the company's reputation, and result in potential revenue loss. Therefore, it is essential to address these waste-related issues and strive for continuous improvement in the production process to maintain high-quality standards and enhance the company's market position.

The investigator aims to explore the implementation of production process control using statistical process control techniques, as outlined by Ploypanitcharoen (2005). Moreover, the application of statistical process control served as a tool to monitor the production process, raising employee awareness about waste occurrence. It would enable management to understand the actual capabilities of the production process, identify areas requiring improvement, and ultimately enhance product quality to meet customer demands. Aiming to prevent waste generation throughout the entire production process, from the initial to the final stages.

2. Objectives

1) To reduce waste in the process of stamping can caps.
2) To increase the efficiency of the production process.

3. Materials and Methods

The data on number of wastes produced in 2021 was provided by the quality control department of a sample company which is the largest metal packaging companies in Thailand. The data was analyzed using Minitab V.14.0 program.

An analysis of waste problems in the process of stamping can lids using quality measurement tools such as Pareto graphs, fishbone charts and analyzing the causes of problems with high waste proportions using P-Chart control charts.

The steps of Planning for improvements was conducted based on 7 steps 1) Study and gather information on current cap stamping processes and quality control; 2) Plan the use statistical quality control to control production and reduce the amount of waste that exceeds the acceptable limits; 3) use the information obtained from the data analyzed by the Minitab package, shown in the form of a Paretto chart to inspect the most problematic waste. Should be improved in cap stamping process; 4) use the information obtained from the data analyzed by the Minitab package, shown in the form of a control chart to illustrate the extent of waste occurring and to find the cause of what happened; 5) Select the cause of the problem that causes the most waste and propose a solution to improve it; 6) Predict the outcome using the Minitab package if the sample company implements the proposed improvement ideas. How much waste and expenses can be reduced; 7) Summary of study results and recommendations (Wanchalerm, 2014; Benjapattanamongkol, 2015).

4. Result and Discussion

4.1 Number of defected products

All data was collected from a leading can lid manufacturing company located in Samutprakarn district, Thailand, with a significant export presence. The company recognizes the importance of implementing methods to reduce defects during production, as this is a critical factor in enhancing its profitability.

From January to July 2021, the company experienced a high volume of defective products while using the Manual Stolle Mega machine, as detailed in Table 1.

Table 1 Amount of Waste Generated from January to July 2021

Month	Amount of production (pieces)	Number of scraps (pieces)
January	4,000,000	15,345
February	7,000,000	45,212
March	4,000,000	16,796
April	4,500,000	17,948
May	6,800,000	37,859
June	4,500,000	18,940
July	5,500,000	32,574
Total	**36,300,000**	**184,674**

From Table 1, data collected from January to July 2021 revealed that the total number of waste products in the sample company with the aforementioned defect characteristics amounted to 184,674 pieces and accounted for 0.51%, with 184,674 defective pieces out of the total production of 36,300,000 units. This waste comprised 75,218 pieces of scratched defective products, 42,660 pieces of tires that are not filled with caps, 27,516 pieces of caps that are wrinkled, 21,551 dented pieces, and 17,729 black lid pieces.

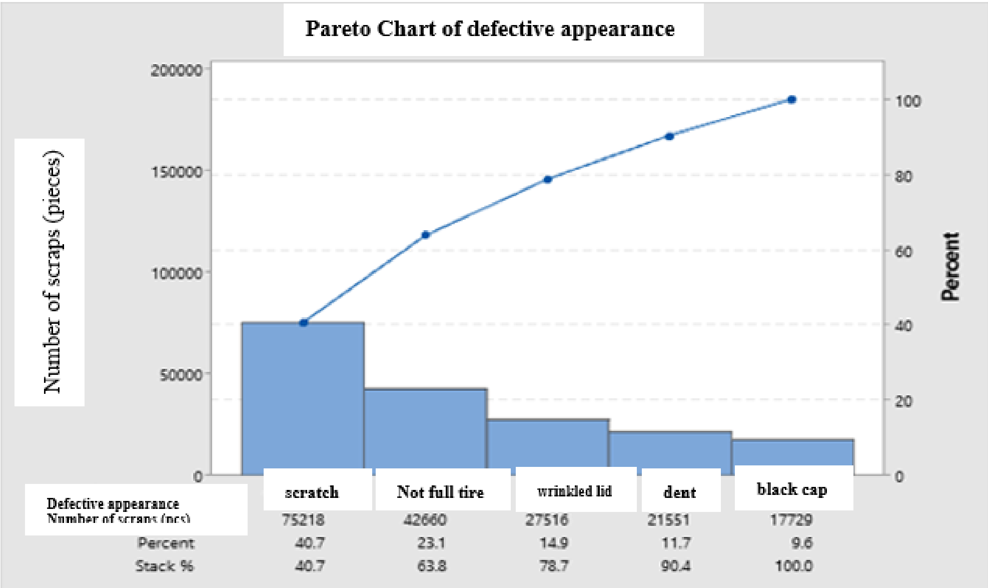

Figure 4 Comparison of the defective characteristics of the stamping can caps produced in the year 2021

The findings from Figure 4 demonstrate that scratched waste accounts for the majority of defects, comprising 40.73% of the total waste, which is consistent with the results reported by Sriprasit (2014). Consequently, this study concentrates on analyzing methods to reduce the occurrence of scratched products.

To ascertain if the waste volume exceeds the minimum thresholds, the lower control limit (LCL) and the upper control limit (UCL) were calculated using the P-Chart control chart. Data on the number of scratched products for every 500,000 units produced was collected from January to July 2021and presented in Table 2.

Table 2 Number of scratched wastes of can lid products

inspection point	Produced quantity (pieces)	Scratch (piece)
1	500,000	984
2	500,000	994
3	500,000	978
…….	……..	……..
69	500,000	962
70	500,000	970
Total	**35,000,000**	**75,218**

4.2 P-Chart control chart,

The occurrence of scratched defects was analyzed using a P-Chart control chart, which displayed the proportion of scratched defects. Each point on the chart represents a total production of 500,000 pieces, illustrating the extent of defects occurring.

The coordinates of the waste proportion control chart (P-Chart) was calculated by the equation as follows:

$$\mathrm{CL} = \bar{\bar{\mathrm{P}}}$$

$$\mathrm{UCL} = \bar{\bar{\mathrm{P}}} + 3\sqrt{\frac{\mathrm{P}\,(1-\bar{\mathrm{P}})}{n}}$$

$$\mathrm{LCL} = \bar{\bar{\mathrm{P}}} - 3\sqrt{\frac{\mathrm{P}\,(1-\bar{\mathrm{P}})}{n}}$$

Which LCL = control coordinates below
UCL = upper control coordinates
n = sample size

Replace

CL = P = 75218/35,000,000 = 0.00215
UCL = 0.00215+ 3√ ((0.00215(1-0.00215))/70) = 0.0187
LCL = 0.00215- 3√ ((0.00215(1-0.00215))/70) = 0

Figure 5 showed the P Chart of scratches workpieces.

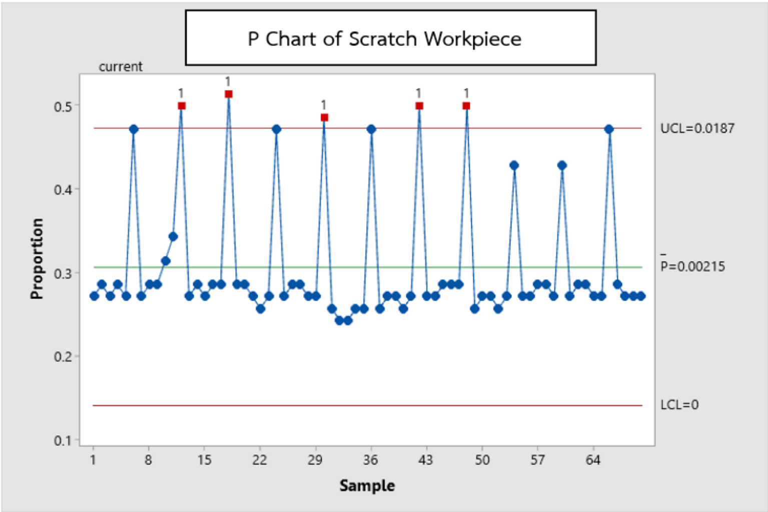

Figure 5 Control chart showing the occurrence of scratched workpiece defects.

The plot demonstrated the proportion of waste products for every 500,000 pieces of can lids, with the Upper Control Limit (UCL) ranging between 0 and 0.0187, representing the acceptable amount of waste products. However, proportions higher than 0.0187 indicate an unacceptable amount of waste products, signaling that management should take measures to minimize loss.

4.3 problem analysis

It is known that the occurrence of defects is scratches caused by many reasons (Sriprasit, 2014). In analyzing the cause of the problem, a quality tool called a cause-and-effect map was used to help classify groups of factors that may cause problems in production. Establish the cause of the problem as shown in Figure 6.

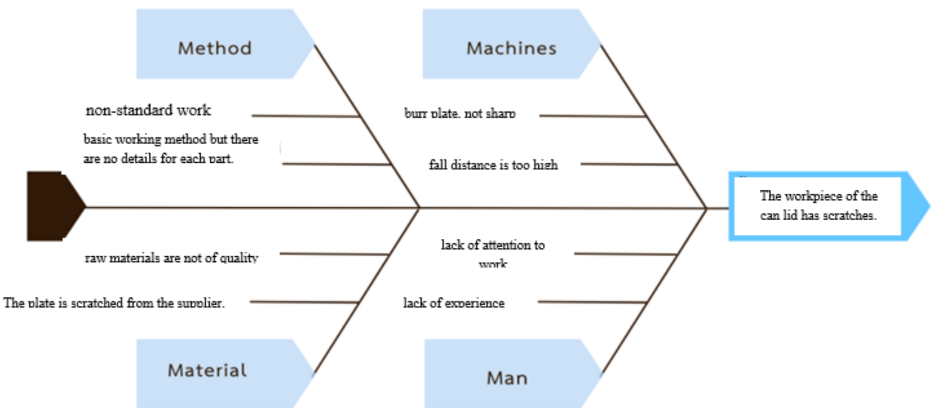

Figure 6 Schematic showing the cause and effect of the problem of scratched workpieces.

From the fishbone diagram, it is possible to identify factors affecting the occurrence of scratches on workpieces during the can lid stamping process by employing the 4M principles: Man, Machine, Material, and Method (Sutthida, 2013). These principles aid in examining the following aspects:

1) Man
   - Lack of attention to work due to insufficient motivation and work-related fatigue.
   - Inexperience arising from constant recruitment of new employees, leading to errors and delays due to inadequate work skills.
2) Method
   - Non-standard practices: employees' carelessness in sorting raw materials for the production process results in a significant amount of waste.
   - While a basic work method is in place, it lacks detailed specifications for each component.
3) Machine
   - Burr formation on the plate edges due to a dull cutting edge from prolonged use.
   - Excessive distance between the deposition and the stamping machine.
4) Material
   - Poor quality raw materials or defects that are not visible to the naked eye.
   - Sheet welding issues from the supplier.

In conclusion, the problem of scratched workpieces in the sample factory is attributed to four factors: people, work methods, machinery, and raw materials. The primary cause, work methods, was chosen for improvement, as it resulted in the largest amount of waste.

Moreover, a tool must be used to analyze the cause of the scratched workpiece problem, namely, the "Why Why Analysis" theory, a question "why" based on factors and characteristics involved in the work process to get to the real cause. In this case, the cause of the analysis was divided into 3 parts: people, methods of operation, and machinery. The raw material with scratch problem from the supplier is not the cause of the problem because it has been inspected before being imported into the production process and therefore is not analyzed as shown in Figure 7.

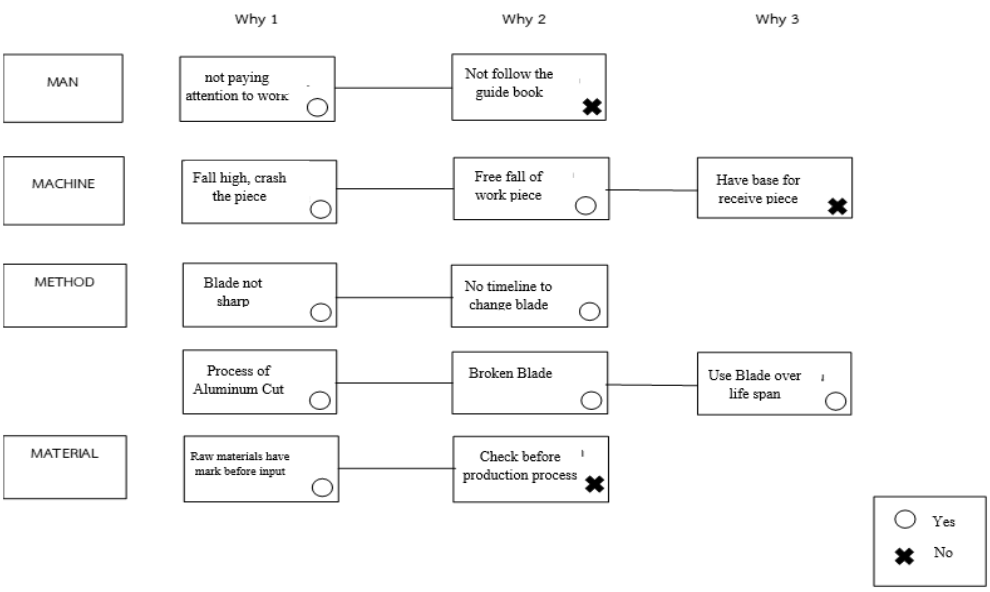

Figure 7 The "Why Why Analysis" diagram for the analysis of the cause of scratched workpieces.

4.4 Proposed improvement methods

The suggested improvements for addressing waste issues can be organized according to the following causes:

Blade-related issues:

Cause: Scratches on workpieces due to cutting aluminum sheets before the stamping process, blade wear, and the absence of blade maintenance and replacement protocols.

Improvement method: Implement a check sheet to monitor workpiece output from the cutting machine. Replace blades after every 2,500,000 pieces, based on the quality control staff's (QC) decisions. Establish maintenance measures for press machine blades.

Human-related issues:

Causes: Lack of employee care, negligence, inadequate machine checks, and inexperienced employees lacking basic knowledge and decision-making abilities.

Improvement approaches: Provide training and introduce best practices to all relevant employees. Increase training frequency with sessions scheduled every six months and monthly meetings for performance reporting and problem-solving.

Method-related issues:

Cause: Insufficient inspection frequencies, poor raw material sorting, and neglect in machine conditions monitoring.

Improvement approach: Record machine conditions twice a day, perform random inspections by department heads, and ensure technicians are always available. Implement a Weekly Checkup Sheet for regular inspection and cleaning. Monitor raw material arrangement for smooth operations.

Raw material-related issues:

Cause: Internal and external factors affecting raw material quality, such as improper covering and non-compliant sheets from suppliers.

Improvement approach: Inspect raw materials before use, clean materials before moving, and prepare appropriate storage spaces.

4.4 Improvement for the production process using the Manual Stolle Mega machine

Based on the approach to reducing waste in the production process of the Manual Stolle Mega machine, focusing on scratches, the emphasis is on the improvement process targeting scratches caused by blades. The researcher has therefore implemented two improvement methods for cutting blades in the slitting machine and blades in the stamping machine. It was found that when the production volume reaches 3,000,000 pieces for the slitting machine blades, the blades' service life is determined. However, the researcher suggests changing the blades at a production volume of 2,500,000 pieces, as changing them at 3,000,000 pieces may result in waste generation. Therefore, a Check Sheet was designed to help monitor the production volume from the slitting machine. Once the specified volume of 2,500,000 pieces is reached, the blades should be changed, with the decision being based on the quality control (QC) employee's discretion. Establish maintenance measures for blades in the stamping machine before they become damaged or worn out. This can be achieved by inspecting the machine's condition, cleaning, and lubricating properly, and adjusting the machine to work according to the maintenance manual's recommendations.

The researcher performed a content analysis combined with the data on blade prices and the price of can lid pieces to compare expenses. If the sample company adopts the working method from the improvement guidelines, it could be beneficial.

4.5 Comparison of waste value after implementation

From the analysis, it is evident that blades that have not been replaced according to their service life have a significant impact on the generation of waste in the form of scratches. However, waste types such as incomplete rubber caps, wrinkled caps, dents, and black caps are not greatly affected. The study shows that waste is generated from blades that have not been replaced according to their service life, resulting in dull and broken blades. This requires time for adjusting and setting up new blades (Chawanparitti, 2018). If the factory under study implements the suggested improvement methods, they will be able to reduce waste as shown in Table 3.

Table 3 Scratched Waste of Can Lid Products before and after running with Improvement Guide.

inspection point	Produced quantity (pieces)	**Scratch (piece)** Before	**Scratch (piece)** After
1	500,000	984	203
2	500,000	994	214
3	500,000	978	239
……….	………	……..	………
6**9**	500,000	962	262
70	500,000	970	270
Total	**35,000,000**	**75,218**	**15,122**

The volume and value of waste before and after the proposed improvements can be calculated (with the production cost of each can lid being 2.547 Baht/piece and the blade replacement cost being 7,000 Baht/time). The percentage of scratched waste compared to the total waste was calculated based on the study of Butphet, Ownsuwan, & Mayureesawan (2018).

Amount of scratched waste compared to the total waste (%)

$$= \frac{\text{Amount of Scratched Waste}}{\text{total amount of waste}} \times 100$$

Replace before improvement; $\frac{75,218}{184,674} \times 100 = 40.73$ %

Replace, Guide after improvement; $\frac{15,122}{124,578} \times 100 = 12.14$ %

Determination of the amount of scratched waste compared to the total waste of the total production.

$$= \frac{\text{Amount of Scratched Waste}}{\text{total production}} \times 100$$

Replace before improvement; $\frac{75,218}{35,000,000} \times 100 = 0.215$ %

Replace, Guide after improvement; $\frac{15,122}{35,000,000} \times 100 = 0.043$ %

Value of waste before and guidelines after improvement (Baht)

= Amount of waste (pieces) × Production cost price (Baht/piece)

Replace before improvement; 75,218× 2.547 = 191,580.24 Baht
Replace, Guide after improvement; 15,122× 2.547 = 38,515.73 Baht

The results were summarized in Table 4.

Table 4 Comparison of Waste Quantity and Percentage Before and After Improvement Approach

Production information	Total amount of waste (piece)	The waste is scratched (piece)	The number of scratched wastes (piece)		Value of waste (Baht)	All production costs (Baht)
			Compared to total waste (%)	Compared to the total production (%)		
Before Improvement	184,647	75,218	40.73	0.215	191,580.24	268,578.77
After Improvement	124,578	15,122	12.14	0.043	38,515.73	136,515.73
Decrease	60,096		28.59	0.172	153,064.51	132,063.03

It was shown that before the improvement, there was a total of 184,674 defective pieces from January to July 2021. Out of these, 75,218 pieces (40.73% of the total waste) had scratch marks. This accounted for 0.215% of the total production of the Manual Stolle Mega machine. If the sample company adopts the proposed improvement measures, the total waste in the production process of the Manual Stolle Mega machine could be reduced to 124,578 pieces, with only 15,122 pieces (12.14% of total waste) having scratch marks. This would account for 0.043% of the total production volume of the Manual Stolle Mega machine. As a result, the percentage of waste caused by scratch marks would decrease by 0.172%, or a difference of 28.59%. This would lead to a waste value reduction of 153,064.51 THB (Thai Baht). Additionally, when factoring in the cost of changing the cutting blade, the company could reduce production costs by 132,063.03 THB over seven months, or 222,399 THB per year.

Figure 8 shows the monthly comparison of the production expenses before and after improvement. This supports the effectiveness of the proposed methodology. The expenses before the implementation (black line) are higher than the expenses after the implementation (dot line) for all studying periods.

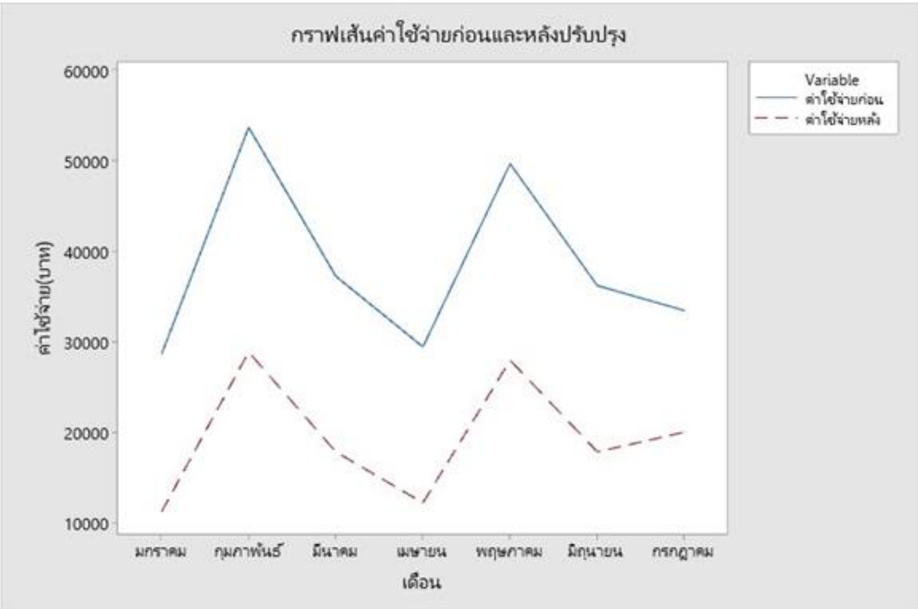

Figure 8 Line graph showing expenses before improvement and guidelines after improvement

5. Conclusion and recommendation

5.1 Conclusion

In the present scenario, the sample company is confronted with quality issues concerning their can lid products. A comprehensive investigation revealed that waste generated during the stamping process is scratches caused by blades. Our research proposes a methodology to manage and reduce waste caused by scratches, primarily resulting from the use of blades beyond their service lifespan. Prior to implementing improvements, waste was generated due to unreplaced, dull, and broken blades. Changing blades required time for setup and significantly impacted the occurrence of waste from scratch. The comparative analysis demonstrates that if the sample company adopts the suggested improvement method, waste could be reduced to 12.14% within the production process, with an estimated value savings of 153,064.51 Baht. Furthermore, this approach has the potential to reduce production costs by 132,063.03 Baht for the 7-month production period, or 222,399 Baht per year.

5.2 Recommendation

This research provides as a guideline for further exploration into the application of statistical process control techniques to address various issues, potentially extending to other departments and enhancing production efficiency. Future research should focus on human resources, as they are a vital component of organizational success. Implementing training programs is crucial for fostering knowledge and understanding of operations. This, in turn, enables effective planning and preparation of personnel, ultimately leading to increased efficiency and effectiveness within the organization.

6. Acknowledgements

Thank you to the teachers of the Industrial Engineering Field, College of Engineering, Rangsit University.

7. References

Ploypanitcharoen, K. (2005). *Solving business problems by statistical methods*. Bangkok: Publisher of the Technology Promotion Association (Thai-Japanese).

Sriprasit, K. (2014). *Reducing waste in the net forming process by quality control principles with Statistical Science.* A Thesis for Degree of Master of Engineering. Dhurakij Pundit University.

Chawanparitti, C. (2018). *Sustainable Industrial Waste Management*. Bangkok: Book center Chulalongkorn University.

Butphet, R., Ownsuwan, J., & Mayureesawan, T. (2018). *7 Quality Control Tools (7 Quality Control Tools)*. [Online]. Retrieved November 30, 2022 from: https://shorturl.asia/xV89B.

Benjapattanamongkol, S. (2015). *The application of QC 7 Tools to reduce waste in the production process*. A Thesis for Degree of Master of Engineering. Thai-Nichi Institute of Technology.

Wanchalerm, W. (2014). *7 quality tools (7 QC Tools)*.[online]. Retrieved November 30, 2022 from: http://econs.co.th/index.php/2016/07/29/7-qc-tools/