Stamping Process Reduction of Waste from the Production Process for Plastic Parts

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

The objective of this project was to minimize waste in the production process of plastic parts for spray painting jigs. This was achieved by analyzing the root causes of waste using a fishbone chart, based on data collected between April and July 2022. The investigation revealed three primary sources of waste in the production process: scratches, chips, and uneven surfaces. Through the application of the fishbone chart, it was determined that these issues primarily stemmed from the inadequate grip of the fixture on the workpiece. This insufficient grip led to workpieces rotating during production, resulting in damage. Specifically, out of a total production of 210,000 pieces, 85,264 pieces (40.6%) were defective due to this issue. To address this problem, a new fixture was designed and implemented. The outcome of this improvement initiative showcased a remarkable reduction in waste. The initial waste count of 85,264 pieces from the total production of 210,000 pieces (40.6%) was effectively curtailed to 23,152 pieces (11.02%) out of the total production, signifying a noteworthy 29.58% waste reduction, which translates to a decrease of 62,112 scrap pieces, equivalent to an estimated financial savings of approximately 3,726,720 baht.

Keywords: *Reduction of Waste, Production Process, Plastic Parts, Spray Painting Jigs*

1. Introduction

At present, the industrial business of manufacturing parts using computer numerical control (CNC) machines is undergoing a rapid market expansion and is quite competitive, both in terms of the quantity of competition using statistical management techniques consistent with Ploypanitcharoen (2005) and in terms of product quality. Therefore, entrepreneurs should determine the development of important strategies to compete in terms of product quality in this industry. As a result, importance must be given to product development and generating profits for their businesses (Etzel et al., 2004) in order to meet customer needs and lead to lower production costs and increased profits. From the internship in the case study factory, data on plastic parts were collected from April–July 2022, as seen in Table 1. The resulting damage includes scratches, dents, and uneven surfaces, which are divided into percentages as shown in Table 2.

Percentage of waste reduction = (Number of waste pieces / Amount of production) x 100 Equation 1

Table 1 Data on production volume, amount of waste generated, and percentage of waste during April–July 2022

Month	Production quantity (pieces)	Total amount of waste (pieces)	Percentage of waste
April	45,000	17,563	39.0
May	70,000	36,285	51.8
June	40,000	15,458	38.6
July	55,000	15,958	29.0
Total	210,000	85,264	40.60

Table 2 Data on the amount of waste generated according to type

Types of waste	Number of waste (pieces)	Percentage of waste
Scratches	42,632	50
Dented	21,316	25
Surface is not smooth	12,789	15
Others	8,526	10
Total	85,264	100

In the production process, it was found that there were problems with products that did not meet customer specifications. The waste found by the inspection department, which collected statistical data to analyze the percentages of waste and types of waste, studied them to find the causes of the waste of plastic parts. The study was conducted by applying the 7 Quality Control Tools of Industrial Engineering theory technique, choosing the fishbone diagram type from the 7 QC tools in order to solve various quality control problems by collecting actual data in the operations to search for and analyze the real cause of the problems and to help in setting standards and implementing continuous monitoring as a tool to assist with analysis of the real causes of workpiece defects in accordance with the description of Saenphakdee (2023). This provided an understanding of the various factors that support and can be used in production, with workpieces mainly made from polyacetal (polyoxymethylene, POM) materials, which is a type of engineering thermoplastic polymer that is milky white, with very high tensile strength and hardness, and good resistance to abrasion. In response to the amount of waste in the factory, there is a way to reduce the waste of plastic parts produced on CNC machines, which involves plastic parts being placed on fixtures in order to improve production efficiency.

2. Objectives

1) To study the production process to find the causes of plastic parts damage.
2) To reduce the waste in the plastic parts manufacturing process.

3. Materials and Methods

The research process included 1) the products studied, 2) the production process, 3) a study of the waste data from the plastic parts production process, and 4) analysis to find solutions.

3.1 Products studied

The sample company produces plastic parts using CNC machines. The company is committed to improving and developing the quality of its products to meet international standards. The plastic parts produced are mainly made from polyacetal (polyoxymethylene, POM), a thermoplastic polymer. An example of the plastic parts produced by the company is shown in Figure 1.

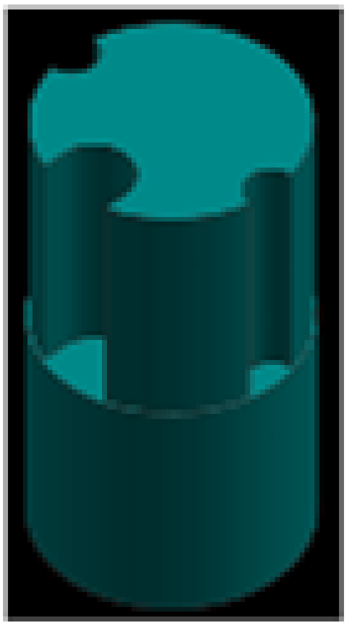

Figure 1 Sample of plastic parts

3.2 Production process

The plastic part manufacturing process of the case study factory as described by Wachararangsi (2024) was used in the fabrication production process. The working steps of the plastic part fabrication process can be summarized as shown in Figure 2.

DESCRIPTION	TIME (min)	SYMBOL ○	⇨	D	□	▽	
1. Prepare materials		●					
2. Assembled with the fixture		●					
3. Bite the work according to the design		●					
4. Check the workpiece					●		
5. Storage of workpieces						●	

Figure 2 Steps of the manufacturing process

Regarding the material preparation, the plastic part molding process begins with the preparation of the materials used to make each part of the workpiece in order to prepare the work before moving on to the next step, as shown in Figure 3 and 4.

Figure 3 and 4 POM materials (polyoxymethylene)

The assembly of the materials with the fixtures is the process of bringing the materials from the material preparation to the turning and milling process. The lathe will hold the workpieces and mill them. The lathe used in the manufacturing process is a CNC lathe as shown in Figure 5.

Figure 5 CNC Lathe

The prepared materials are assembled with the fixture for use in the next step, as shown in Figure 6.

Figure 6 Assembling the prepared materials with the fixture (CNC lathe)

Machining according to the design involves the use of CNC machines to mill the workpieces to the form of the plastic part, as shown in Figure 7.

Figure 7 Drilling machine

After the turning according to the model, the workpieces must be inspected for smoothness and to obtain the dimensions according to the plastic part model, as shown in Figure 8.

Figure 8 Finished machined workpieces ready for assembly

After checking the correctness and obtaining the size according to the plastic part model, the inspected pieces will be stored as shown in Figure 9.

Figure 9 Collection of the pieces for use in the next step.

3.3 Study of waste data from the plastic parts production process

From the data collection in the case study factory during April–July 2022, it was retrospectively found that from the total production of 210,000 pieces, there were 85,264 waste pieces, which is 40.60% of the total production amount.

Percentage of waste reduction = (Number of waste pieces / Amount of production) x 100 Equation 1

The defective characteristics of the plastic parts, which are scratches, dents, and uneven surfaces, after being detected from April to July 2022, are shown in Table 3.

Table 3 Data on production volume, amount of waste generated and percentage of waste during April–July 2022 (before improvement).

Month	Production quantity (pieces)	Total amount of waste (pieces)	Percentage of waste
April	45,000	17,563	39.0
May	70,000	36,285	51.8
June	40,000	15,458	38.6
July	55,000	15,958	29.0
Total	210,000	85,264	40.60

3.4 Analysis of information for solutions

From the data in the table, it can be seen that there are numerous reasons that can cause the occurrence of scratch defects. In order to analyze the causes of the problem, a quality control tool called a cause-and-effect (fishbone) diagram, which is one of the seven OC tools consistent with Wannasathit (2022), was used to help classify the groups of factors that may be the cause of production problems. Thus, the causes of the problem were established, as shown in Figure 10.

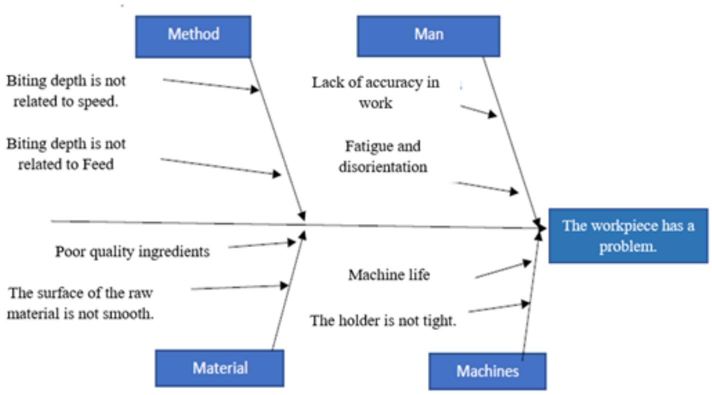

Figure 10 Diagram showing the causes and effects of damaged workpieces

From the fishbone diagram, we can see the causes that result in the damage of the workpieces during the plastic part manufacturing process by using the 4M principle include man, machine, material, and method, as follows:

1) Man: A. Lack of precision in work due to not inserting the workpiece correctly. B. Fatigue during work causes deviations in the workpiece.

2) Method: A. The depth of the cut is not related to the feed. B. The depth of the cut is not related to the feed speed.

3) Machine: A. The machine has had a long service life. B. The clamp is not tight, causing the position of the workpiece to deviate.

4) Raw Material: A. The raw materials are not of good quality, some of which have damage that can be seen by the naked eye. B. The surfaces of some materials are not smooth.

The problems of the damaged workpieces in the sample factory shown in the cause-and-effect diagram were found to be mainly caused by the workers, working methods, machines, and raw materials. Therefore, only one cause, which is machines, was selected to be resolved since machine problems are the main cause of the highest amount of waste based on the analysis by the factory production process experts. Thus, the problems were investigated as follows:

The cause of the problems shown by the cause-and-effect diagram can demonstrate that the problem that causes the most waste is the machine not holding the workpieces tightly, which results in the workpieces being damaged by scratches, as shown in Figure 11.

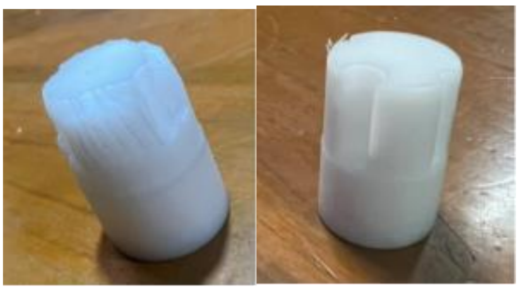

Figure 11 Damaged workpieces

The problem of the damaged workpieces was found to be caused by rotation because the fixture did not hold the workpieces tightly, resulting in imperfect production and a large amount of waste. Therefore, a new fixture was designed and created using low carbon steel (SS45) to solve this problem and increase the number of undamaged plastic workpieces, as shown in Figure 12.

Figure 12 Undamaged plastic parts

From the usage, it was found that the original fixture was only useful for holding the workpieces, which was only one advantage and very minor when compared to the disadvantages, such as scratching the workpieces and not holding them tightly. The main reason for damaging the workpieces was that the original fixture required a screw to lock the workpieces into place, as shown in Figure 13.

Figure 13 Example of the original fixture

From the study and analysis of the data, a new fixture was designed and created. The operation of the original fixture was analyzed, and the new one was developed and improved (Meethong, 2019) to reduce the amount of waste from loose workpieces by using low carbon steel (SS45) as the material.

Fixture Creation Concept

Since the production of plastic parts using the old fixture had the problem of not holding the workpieces tightly, which caused the workpieces to be damaged, we designed a new fixture that may have higher production costs than the old fixture but can reduce the production problems. The new fixture is designed to hold the workpieces at the top so that it can hold them more tightly, thereby reducing damage to the workpieces and making it more convenient to remove and insert them than before.

The new fixture design can provide the details and sizes of each part as well as the details of the name and size of each screw, as shown in Figure 14.

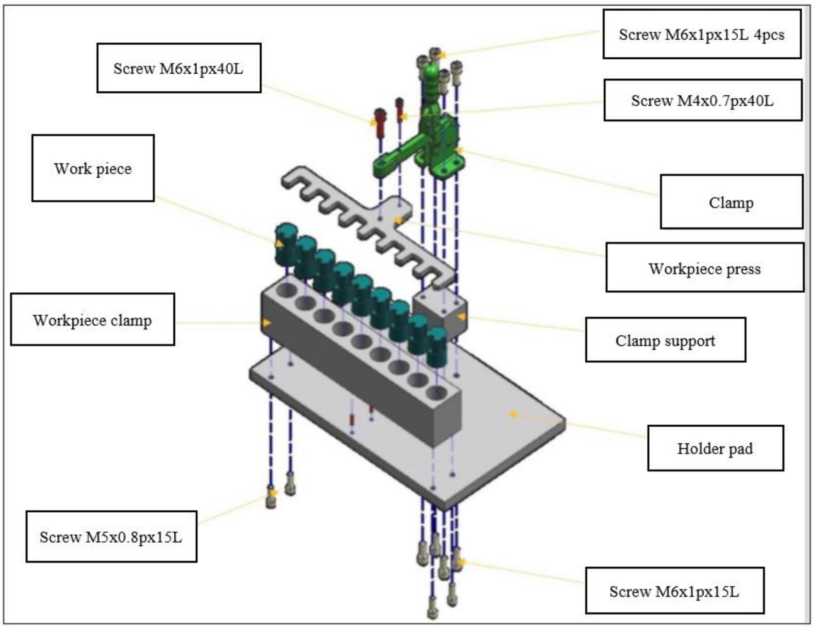

Figure 14 Fixture design and new standard parts details

From Figure 14, it can be seen that each piece can be assembled as shown in Figure 15.

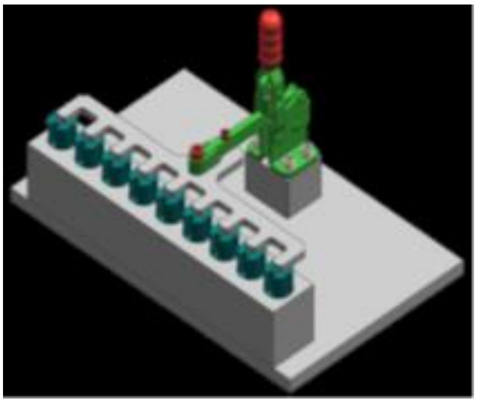

Figure 15 3D sample of the new fixture and standard parts

4. Results and Discussion

4.1 Waste reduction guidelines

From the study, it was found that the problem occurred as a result of the process of clamping the plastic workpieces, causing them to be damaged. Subsequently, this process can be improved based on the causes of the defects as follows:

Causes from the fixture: Many of the workpieces had scratches because while inserting the workpieces into the fixture before proceeding to the workpiece clamping process during the CNC milling, these workpieces were damaged. Thus, the workpieces were scratched because they were not clamped tightly.

Improvement guidelines: Since the production of plastic parts of the original fixture had problems with the workpieces not being held tightly, which caused damage to them, the researchers designed and built a new fixture based on the design-build principle (Meesang, 2023), using low carbon steel (SS45) as the material, which may have higher production costs than the original fixture but can reduce production problems. The new fixture is designed with the workpiece holder on top in order to grip the workpieces more tightly, thereby reducing the scratches on the workpieces and making it more convenient to remove and install the workpieces, as shown in Figure 16.

Figure 16 New Fixture

4.2 Comparison of the study results (before and after improvement)

From the results for the case study after improving the production line, it was indicated that by using the new fixture, the number of defective items was decreased from 85,264 pieces to 23,152 pieces.

The recorded data shows the production volume, the amount of waste generated, and the percentage of waste from April to July 2022, as seen in Table 4.

Table 4 Data on the production volume, amount of waste generated and percentage of waste from April to July 2022 (before improvement of the fixture).

Month	Production quantity (pieces)	Total amount of waste (pieces)	Percentage of waste
April	45,000	17,563	39.0
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June	40,000	15,458	38.6
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Total	210,000	85,264	40.60

From the recorded data, the production volume, amount of waste generated and percentage of waste from September to December 2022 are shown in Table 5.

Table 5 Data on the production volume, amount of waste generated and percentage of waste from September to December 2022 (after improvement of the fixture).

Month	Production quantity (pieces)	Total amount of waste (pieces)	Percentage of waste
September	55,000	6,725	12.2
October	40,000	4,635	11.5
November	70,000	7,312	10.4
December	45,000	4,480	9.9
Total	210,000	23,152	11.02

Based on Table 4 and 5, a graph showing the comparison of the percentage of waste before and after improvement is presented in Figure 17.

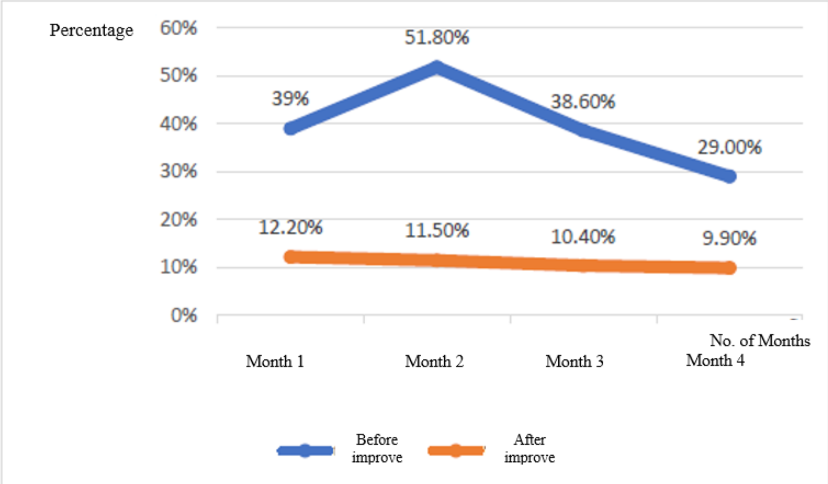

Figure 17 Percentage of waste before and after improvement

Based on Tables 4 and 5, the data can be presented as a graph showing the comparison of the average percentage of waste before and after improvement, as shown in Figure 18.

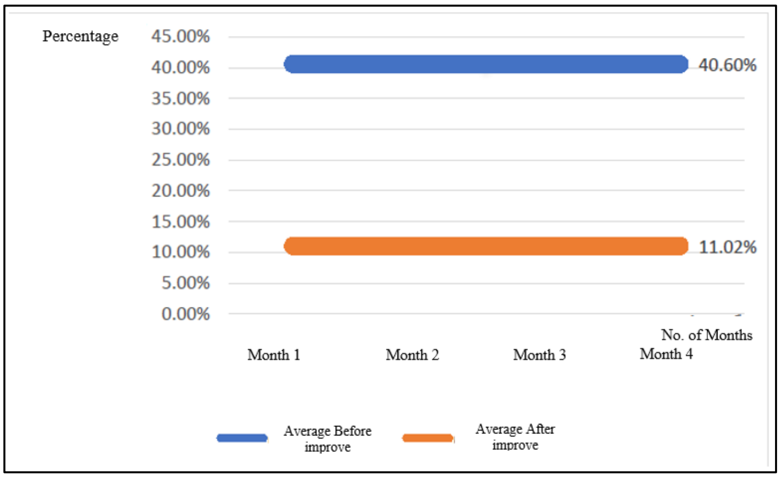

Figure 18 Averages before and after improvement

From Table 4 and 5 and Figures 17 and 18, it can be seen that before the improvement, the average waste was 40.60% of the total production. After designing and implementing a new fixture, it was found that the average waste was 11.02% of the total production (Besterlife, 2022). This means that the percentage of waste could be reduced by 29.58% or the total number of waste pieces could be reduced by 62,112 pieces. Moreover, the cost per piece is approximately 60 baht, totaling approximately 3,726,720 baht.

5. Conclusion and Recommendations

5.1 Conclusion

Because the original fixture did not hold the workpieces tightly, the production was flawed, resulting in a large amount of waste. After improving the work by adjusting the design of the fixture, it was found that the number of defective workpieces in production could be reduced by 29.58%. The results of improving the work process and increasing the production efficiency (Chawanparitti, 2018), including the creation of standard production forms, can be summarized as follows:

1) Reduction of the number of defective production pieces by 29.58%

2) Reduction of the number of plastic parts defects and shortening of the production line. Standard work forms, including fishbone and line charts of the production process before and after improvement and a record of monthly statistics were created, and the best fixture to use to reduce the defects in the production of plastic parts was selected.

From the production data collection, it was found that the damaged production rate during April–July 2022 was 85,264 pieces per month, or 40.60%. It was found that most of the problems in production were caused by poor fixture holding resulting in a lack of precision in holding the workpieces tightly in the production process, as well as the faults of both the fixture and the employees, resulting in problems in production, with some workpieces having scratches or rotating during production, causing damage to them. The comparative results after the factory implemented the new fixture in the production process during September–December 2022 indicate that it was able to reduce the amount of defective workpieces and meet customer needs. It was also able to reduce defective workpieces to 23,152 pieces per month, or 11.02%, which means that it could reduce the percentage of defective workpieces by 29.58% or reduce the total number of defective workpieces by 62,112 pieces, with a cost per piece of approximately 60 baht, totaling a savings of approximately 3,726,720 baht.

5.2 Recommendations

The results of this research can be applied in the next step of waste reduction by using research, development, and continuous improvement, or PDCA, which is an analysis using the principles of Plan-Do-Check-Act, and goal setting to achieve that aim quickly. In this way, the research that approaches the zero-defect process or the process of reducing waste to zero percent will be conducted in future studies.

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