Reviewer comment_1396

This study focuses on identifying and reducing processing time (PT) waste in the injection molding process and shaft assembling process to increase the amount of production.

Abstract

This section should be reviewed entirely by the authors. Please provide a summary of the findings. What did you accomplish with the lean manufacturing method? This was not stated explicitly. The last sentence should be removed.

Introduction

a. Authors should modify this section.
b. The authors should include a paragraph with some review articles about the injection molding process.
c. There should be a linkage with each paragraph in this section.
d. The authors should carefully read this section for grammatical errors.

Results and discussion

a. This section should be scrutinized because some of the discussions are unclear.

Conclusion

a. The authors should go over this section again. More clarification and modification are required.

General comment

a. Authors must proofread the entire manuscript for grammatical errors.
b. The results and discussion should be rephrased.
c. Do the authors consider other factors related to the injection molding machine to reduce or eliminate waste? (Mechanical fault, human errors). These were never addressed throughout the entire study. The root cause analysis mentioned was too narrow and too brief.
d. Can the authors use a statistical approach to support this FGD?

Lean Concept to Reduce Waste of Process Time in the Plastic Injection Industry in Indonesia

ABSTRACT

Mapping has been done previously showing that there are high processing times for the injection molding and shaft assembly processes in the plastics industry type S/A worm gears. The purpose of this study is to identify and reduce waste in the injection molding process and the shaft assembly process to increase the amount of production. The research used the method of lean concept approach with the identification of the causes carried out using the What-Why-Where-When-Who-How (5W+1H) methods in Focus Group Discussions (FGD) with competent parties in their fields. This study found that the type of waste obtained includes the movement of goods from both parts of the process which is too long. This research indicates that the injection molding process time (PT) can be reduced by 32.70% and the shaft assembly process by 37.82% from the current state mapping. The contribution of this research can reduce process time so that it affects increasing plastic production to meet customer demands.

KEYWORDS

Focus Group Discussion, Injection Molding, Lean Concept, Plastic Manufacturing, Value State Mapping

I. INTRODUCTION

Sales of plastic products in the global market in 2019 were valued at USD 568.9 billion and are expected to increase by 3.2% from 2020-2027 (Indonesian Ministry of Industry, 2020). The demand for plastic from various industries such as the infrastructure, automotive, electrical, and electronic industries is also the reason for the increasing consumption of plastic in the global market (Aisyah *et al.*, 2021). In the automotive industry, regulations to reduce vehicle weight and improve fuel efficiency to reduce carbon emissions have encouraged the use of plastics as a substitute for metal base materials, including aluminum and steel. Plastic materials are used as raw materials for the manufacture of automotive components. is expected to support the increasing demand for plastics in the automotive industry (Krishna, 2018)(Hertwich *et al.*, 2019)(Trinks, Mulder and Scholtens, 2020). Plastic sales that dominated the market by 25.70% in 2019 are plastic that is applied for packaging or as packaging (Indonesian Ministry of Industry, 2020). This sale was due to increased demand from

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the packaging sector, which includes containers and bottles, plastic bags, plastic films, and geomembranes. The top four biggest global plastic market sizes come from the food and beverage industry, cosmetic industry, electronic, and automotive industries (Gaikindo, 2020).

In the Southeast Asia region, especially Indonesia, per-capita plastic consumption per year is 10 kg, and it is predicted that it will increase like other ASEAN countries which can reach 40 kg per-capita each year such as Singapore, Malaysia, and Thailand (Rozak, Jaqin and Hasbullah, 2020). The Ministry of Industry noted that the growth of the plastic and rubber industry in 2018 grew by 6.92% on an annual basis, an increase compared to the previous year which was recorded at 2.47%. The number of plastic industries to date has reached 892 companies that produce various kinds of plastic products. This sector employs a workforce of 177,300 people and has a total production of 7.23 million tons which has increased by five percent in the last five years. This industrial trend is also triggered by market growth in Indonesia, where the plastic and rubber industry is a sector that has priority development from the Indonesian government following the national industry development indication plan (Indonesian Ministry of Industry, 2020).

Plastic manufacturing is one of the important industrial sectors because the process starts from upstream to downstream, the plastic industry also plays an important role in the supply chain process for other industrial sectors (Oktavilia *et al.*, 2020)(Chauhan, Khandekar and Zagade, 2020)(Dănuţ-Sorin, Opran and Lamanna, 2020). The intense competition in the plastics industry encourages companies to respond quickly and precisely to problems that occur in their operational activities. Injection molding is a manufacturing technique for making products derived from thermosets into thermoplastics that have complex characteristics with varying sizes, high production speeds, and accurate dimension (Siregar, Khan and Umurani, 2017)(Gomes *et al.*, 2017)(Desai and Prajapati, 2017).

Based on the phenomenon, some of the problems that have occurred so far at this company are the low productivity resulting from the wasting of too long processing time in the production department so that the target is not achieved in meeting customer demands. The company needs to streamline the production process so that a more effective and efficient production line will be created by reducing waste on activities that are too long in the process so that it will increase the amount of production (Kumar, M.Parthasarathi and Manojkumar, 2016)(Khairunnisa, Hidayati and Shalihin, 2020). Based on some of these problems, the company needs a strategy or method that can reduce the waste of process time in the production section, namely the lean concept for solutions to eliminate waste, reduce non-value-added operations, and increase value-added operations so that the results are as desired (Nallusamy and Adil Ahamed, 2017).

The gap analysis in research (Siregar *et al.*, 2018) has explained that process time waste can be eliminated in fan production, while research (Kaneku-Orbegozo *et al.*, 2019). has succeeded in reducing the process of production time on kitchen equipment. While this research will discuss how the lean concept can reduce the waste of time in the production process for S/A worm gear products in the plastic injection industry. The new approach of this research method used the Lean concept approach with the identification of the causes carried out using the What-Why-Where-When-Who-How (5W+1H) approach and why-why analysis in Focus Group Discussions (FGD) with competent parties in their fields. This study aims to identify and reduce processing time (PT) waste in the injection molding process and shaft assembling process to increase the amount of production.

II. THEORETICAL ANALYSIS

In this section, a theoretical analysis that is relevant to the object and method used will be discussed, because it is to support this research reference.

A. Injection Molding

The injection molding process begins with inserting the plastic ore into the hopper. The plastic ore is then melted and goes to the barrel, which contains a screw that functions to flow the melted plastic ore material to the nozzle (Ramakrishnan and Nallusamy, 2017). Injection molding is one of the common methods used by plastics companies because of its high efficiency and durability (Patel *et al.*, 2021). Injection molding is divided into 4 main stages: filling, cooling, packaging, and injection (Gunturu *et al.*, 2020). Plastic injection is a method in which using extruder plastic granules are injected into a hole with high pressure and temperature to produce a strong plastic material (Rahimi *et al.*, 2018).

B. Lean Manufacturing

Production activities that focus on reducing waste in all aspects of a company's production activities are called lean manufacturing methods in fan products (Siregar *et al.*, 2018), used VSM (Zahrotun and Taufiq, 2018)(Maria *et al.*, 2019), and can be combined with the Six Sigma method to reduce manufacturing defects (Kurnia and Hardi Purba, 2021). Lean thinking is lean because it provides a way to do better things by using as few resources as possible, namely less human effort, less equipment, less time, and less space by continuously approaching what customers want (Engelseth and Gundersen, 2018), and the removal of carbon dioxide (CO2) from natural gas (Salaudeen, Bopbekov and Abdulkarim, 2022). The application of the lean concept is one of the sustainable strategies that can be used by various industries to improve manufacturing performance and reduce waste, this is based on research (Kaneku-Orbegozo *et al.*, 2019), and can be applied in healthcare (Sukma *et al.*, 2022). This lean method is a sustainable strategy to reduce waste and can provide effective results to optimize production costs efficiently (K. Liker and Meier, 2006), company's productivity will increase by eliminating waste (Prayugo and Zhong, 2021).

III. METHODOLOGY

In this section, the steps of the lean concept can be implemented in the plastic injection industry. The limitation of this research is only on the dominant process in producing waste of time in the process of making S/A worm gear. The application of the lean concept in the manufacturing industry is carried out in the form of case studies and analyses of effectiveness in manufacturing companies (Mahato, Rai Dixit and Agrawal, 2017)(Zahoor *et al.*, 2018). The improvement tool used to eliminate waste is Value Stream Mapping (VSM), this tool analyzes all identification activities that do not have added value (waste) (Ikatrinasari, Hasibuan and Kosasih, 2018). Furthermore, improvements are designed so that waste is reduced or even eliminated (Figure 1).

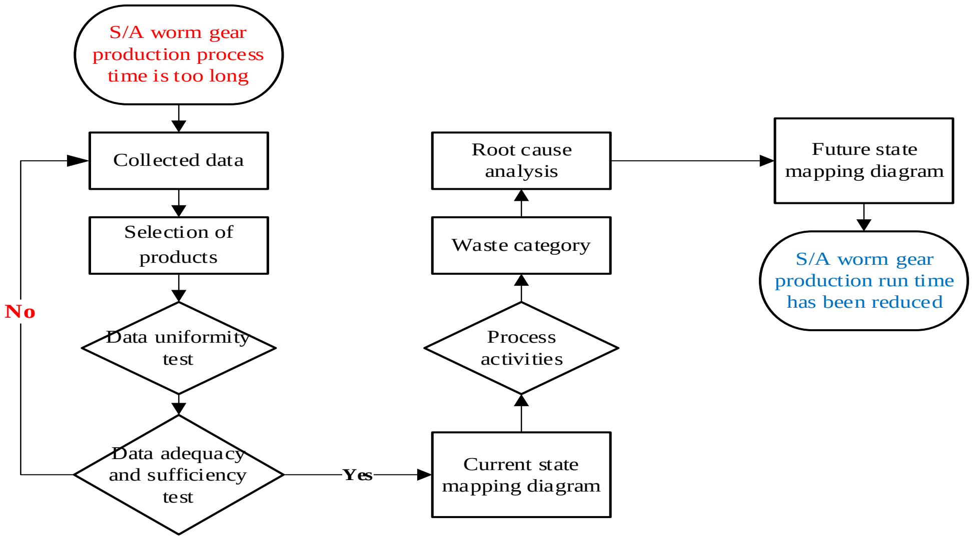

Figure 1. Study framework

Based on Figure 1 it can be explained that this research started with old PT injection molding and shaft assembling so that production was disrupted, then data collection was carried out in the form of monthly report documents for 6 months. After that, a Pareto diagram is made of the most dominant product family in production, then the demand from customers is broken down every month for the dominant product family item. The next step is Current State Mapping (CSM) by determining the uniformity of the data, data adequacy test, and data sufficiency that appears in each process taken from 30 trials. The formula that has been used can be seen below:

1) Cycle time (CT) = $\bar{X} = \frac{\sum X_i}{n}$ (1)

2) Standard deviation (SD) = $\sigma = \sqrt{\frac{\sum (X - \bar{X})^2}{n - 1}}$ (2)

3) Upper control limit (UCL) and lower control limit (LCL)

$\text{UCL} = \bar{X} + 2(\sigma)$ (3)

$\text{LCL} = \bar{X} - 2(\sigma)$ (4)

4) Normal time (NT) $= \bar{X} \times p$ (5)

5) Standard time (ST) $= \text{NT} + \frac{100\%}{(100\% - 5\%)}$

(6)

6) Data adequacy test = $N' = \left[\frac{\frac{k}{s}\sqrt{(N \times \sum X^2) - (\sum X)^2}}{\sum X}\right]^2$ (7)

After the CSM diagram is determined, the next step is to analyze the identification of waste starting from the activation process which is Value Added (VA), Non-Value Added (NVA), and Necessary but Not Value Added (NNVA). After that, you can determine the waste category from the injection molding process and the shaft assembly process. After data collection, data analysis, and the dominant causes of PT from injection molding and shaft assembling have been known, the next action is to make improvements starting with conducting FGD to determine the root cause analysis with why-why analysis and 5W+1H, This method has also been applied when determining 5W+1H in reducing elastic tape defects (Kurnia, Jaqin and Manurung, 2022). After all corrective actions have been taken from the two processes (injection molding process and shaft assembling process), the next step is to measure FSM to determine the decrease in processing time.

IV. RESULTS AND DISCUSSION

The selection of products whose process is mapped can be determined by selecting based on the number of products or based on the production route that has the most frequency. The approach used in the case study of this company is based on the number of products. This research has indicated that the determining factor in the selection is not only in terms of quantity but also considers the selling value of the product and the A/R ratio (the ratio between the level of production and the level of demand). The selection of products whose process flow is mapped is based on two criteria, namely the number of orders and the selling value. The data collected is only for products that have been produced for at least 1 year, this criterion is used to obtain products that are still produced in the long term so that the development carried out is right on target. For more details related to the results of the production can be seen in Figure 2.

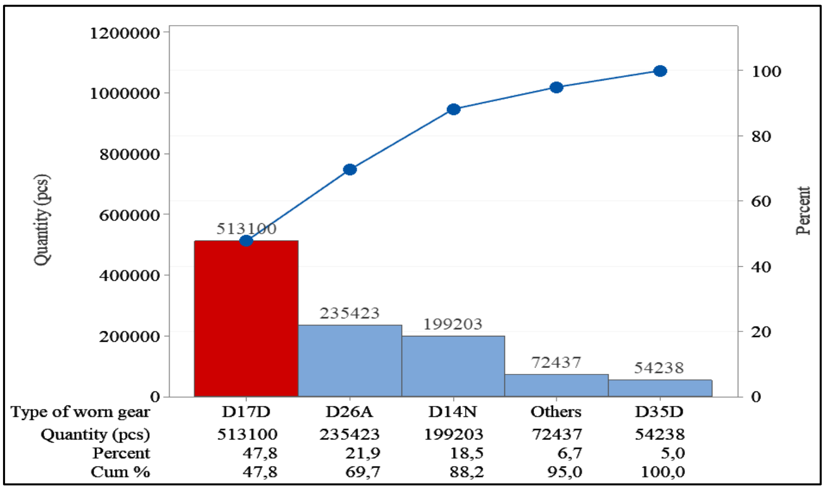

Figure 2. Production of gear worm S/A

In figure 2, it can be seen that in the daily data collection above, the decision was taken to make a VSM of the D17D type S/A worm gear product because this product has a percentage of 47.8% from other types of product families. This product goes through the entire production process starting from material and compound, material receiving the check, injection molding, visual check, and packing.

After getting the type of S/A worm gear product that has the highest production percentage, then the current status flow mapping is carried out on the D17D type product.

The number of production requests has been known, namely the production demand data for the S/A D17D type worm gear product as input in the CSM design. This number of production requests is used as the basis for reference to the value-added time of the entire production process in producing S/A type D17D gear worm products. This production amount is obtained from company data based on customer requirements for the D17D type S/A gear worm shown in Figure 3. The average production for S/A gear worm type D17D is 257500 pcs per 6 months or an average of 42917 pcs per month. This means the average production per day is equal to 2145 units per day (20 working days/month).

A. Current Value State Mapping

Production process and time: At this stage, the flow of the S/A gear worm production process can be seen in the operational process chart which can be seen as the chart in Figure 4 (operation process: 3, checking process: 2, storage: 2).

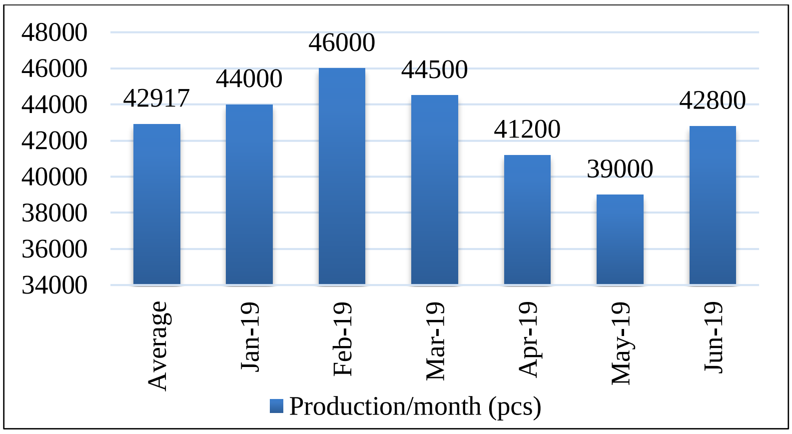

Figure 3. Total production for gear worm S/A type D17D Jan-Jun 2019

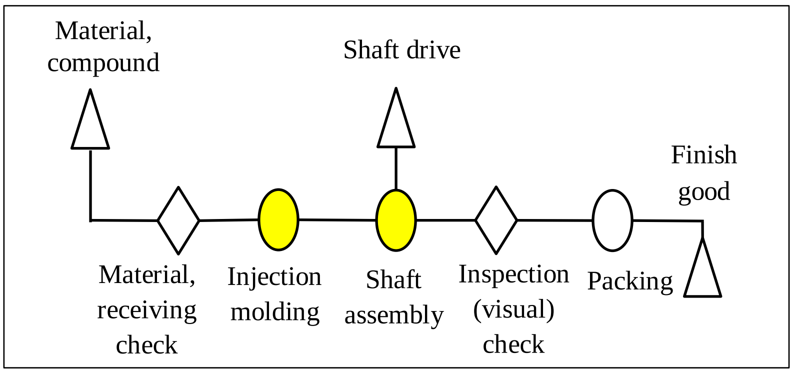

Figure 4. Operation process chart of gear worm S/A

Production process cycle time: At this stage, we explain the cycle time of the D17D type S/A gear worm production process. There are several stages in the production process of type S/A D17D dental worms with the number of CT for 30 trials of 2,936.9 seconds, including:

Data uniformity test, this test is a test to ensure that the data cycle time comes from the same system. The following is an observation of the time of each production process for the D17D type S/A gear worm.

1) CT = $\overline{X} = \frac{2{,}936.9}{30} = 97.90$ sec
2) SD = $\sigma = \sqrt{\frac{4.55}{30-1}} = 0.40$ sec
3) In this calculation using a 95% confidence level with a value of k = 2 with the following calculation results:
   $\text{UCL} = 97.90 + 2(0.40) = 98.69 \text{ sec}$ $\text{LCL} = 97.90 - 2(0.40) = 97.10 \text{ sec}$
4) Normal time = In this calculation using the Westinghouse approach:

$$\text{Skill} = \text{Average (D)} = 0.00$$
$$\text{Effort} = \text{Average (D)} = 0.00$$
$$\text{Condition} = \text{Fair (E)} = -0.03$$
$$\text{Consistency} = \text{Fair (E)} = -0.02$$
$$\text{Amount} = -0.05$$
$$\text{then, p} = 1 - 0.05 = 0.95$$
$$\text{Normal time} = 97.90 \times 0.95 = 93.00 \text{ sec}$$

5) Standard time is calculated by 5% leeway from normal time with the following calculation results: $\text{ST} = 93.00 + \frac{100\%}{(100\% - 5\%)} = 94.05$ sec
6) Adequacy test result:

$$\text{N}' = \left[\frac{\frac{2}{\frac{1}{10}}\sqrt{(30\ x\ 351.00) - 9801.00}}{99}\right]^2$$

$$\text{N}' = \left[\frac{20\sqrt{729}}{99}\right]^2$$

$$\text{N}' = \left[\frac{540}{99}\right]^2 = 29.75$$

Table 1 is the result of the data uniformity test from the measurement of the production process time of the S/A gear worm for the D17D type. Data adequacy test, this test is a test to ensure that the cycle time observation data has sufficient data. The following is an observation of the time of each production process for the D17D type S/A gear worm.

Table 2 is the result of the data adequacy test from the measurement of the production process time of the S/A D17D type worm gear that has been obtained, with the results N' < N can be stated the total number of observations is sufficient. Based on the amount and time of production, business process re-engineering production (VA and NVA), production cycle time, and the number of rejects for the production of D17D type S/A worm gears, a current state mapping is formed in the S/A worm gear production process. type D17D, more detail can be seen in Figure 5.

Table 1. Data Uniformity Test Results

No	Work station	Activity	Cycle time (sec)	UCL (sec)	LCL (sec)	Normal time (sec)	Standard time (sec)
1	Injection molding	Setting machine	97.90	98.69	97.10	93.00	94.05
2	Injection molding	Running machine	17.72	18.27	17.18	16.84	17.89
3	Injection molding	Check F/G	4.56	4.69	4.42	4.33	5.38
4	Material receiving check	Material check	9.56	9.69	9.42	9.08	10.13
5	Shaft assembly	Setting machine	9.52	9.69	9.34	9.04	10.09
6	Shaft assembly	Setting Jig	25.51	26.86	24.17	24.24	25.29
7	Shaft assembly	Setting product & running process	14.10	15.17	13.02	13.39	14.44
8	Inspection (visual check)	Visual check	10.39	11.53	9.24	9.87	10.92
9	Packing	Placement product inbox	5.62	6.63	4.61	5.34	6.39

Table 2. Data Sufficiency Test Results

Workstation	Activity	Σx	$(\Sigma x)^2$	Σx^2	$N\Sigma x^2$	N'
Material receiving check	Material check	99.00	9,801.00	351.00	10,529.83	29.75
Injection molding	Setting the program	97.00	9,409.00	335.00	10,050.00	27.25
	Running process	107.00	11,449.00	405.00	12,150.00	24.49
	Check Finish Good	111.00	12,321.00	437.00	13,110.00	25.61
Shaft assembly	Setting the machine	105.00	11,025.00	389.00	11,670.00	23.40
	Setting the Jig	92.00	8,464.00	302.00	9,060.00	28.17
	Setting the product & running process	94.00	8,836.00	314.00	9,420.00	26.44
Inspection (visual check)	Visual check	91.00	8,281.00	295.00	8,850.00	27.48
Packing	Placement of product in the box	92.00	8,464.00	302.00	9,060.00	28.17

Figure 5, about the results of the CSM diagram, the injection molding process has a reject ratio of 83.69% with a cycle time of 120.18 seconds and the shaft assembly process has a reject ratio of 15.58% with a cycle time of 49.13 seconds as a critical process for further analysis and can be increased in the production of type D17D S/A worm gears. Based on the high processing time on the production line, corrective action is needed to minimize the process, and streamline the production process to support high customer demand. Thus the production process needs to apply the concept of lean manufacturing to get a fast processing time and increase productivity.

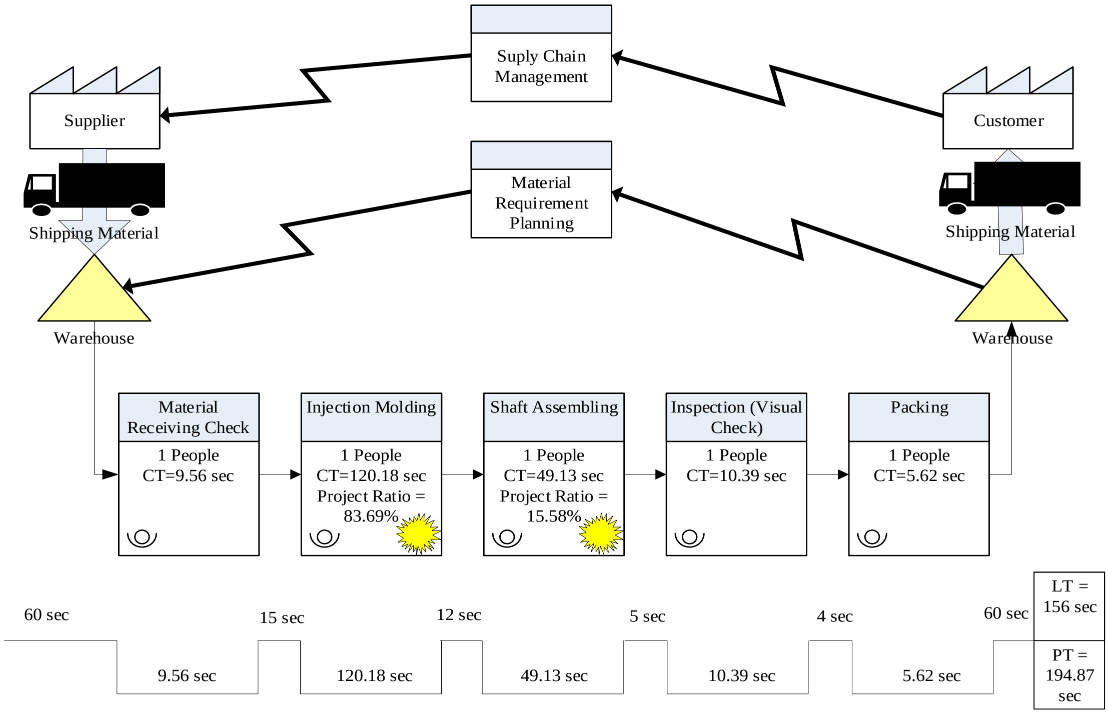

Figure 5. Current State Mapping Diagram

B. Waste Identification

The results of observations regarding process activities in the injection molding process and the shaft assembly process are shown in Table 3. Based on Table 3 about the activity data on the molding injection and shaft assembly processes, there are 2 VA activities with a total activity time of 31.82 seconds and 4 activities that are NNVA with a total activity time of 137.49 seconds. Based on the identification of activities that have been found in the Injection molding and shaft assembly processes, 4 activities are necessary but not added value. At the stage of each activity that is not value-added and activities that are necessary but not added value can be categorized as every type of waste that occurs. The following are categories of waste that occur in the Injection molding and shaft assembly processes from non-value-added activities and necessary but NVA activities. More details related can be seen in Table 4.

Table 3. Injection Molding and Shaft Assembly Process Activities

Process	Activity	Activity identification	Time (sec)	Classification		
				VA	NVA	NNVA
Injection molding	Setting machine	Setting the program or fixture on the machine	97.90			√
		Running process	17.72	√		
		Check finish goods	4.56			√
Shaft assembly	Setting machine	Setting the program on the machine	9.52			√
		Setting the Jig or fixture on the machine	25.51			√
	Setting product	Install the product on Jig, run process, and check finish goods	14.10	√		
Total				31.82 sec		137.49 sec

Table 4. Activity Identification of Waste in the Injection Molding and Shaft Assembly Process

Process	Activity	Activity identification	Activity description	Time (sec)	Weight	Waste category
Injection molding	Setting the machine	Setting the program or fixture on the machine	Setting up programs molds or fixtures for the Injection molding process on machines	97.9	95.55	Processing
		Check finish goods	Checking the results of the print	4.56	4.45	Motion
Shaft assembly	Setting the machine	Setting the Jig on the machine	Setting up the jig for the shaft assembly process on the machine	25.51	72.82	Processing
		Setting the programs or fixtures in the assembly process	Setting up programs or fixtures for the shaft assembly process on the machine	9.52	27.17	Processing

Based on Table 4 the type of waste processing in the program setting activity, jig, and fixtures on the machine has the largest weight, namely 95.55% for the injection molding process and 72.82% for the jig setting activity for the shaft assembly process from the total processing time.

C. Root Cause Analysis

Based on the waste category found with the highest weight in the Injection molding and shaft assembly processes, an analysis was carried out to find the root cause of the process. The analysis in finding the root of the problem uses the why-why analysis and the 5W+1H methods. This why-why analysis is carried out by maintenance, production, engineering, and quality control parties in an FGD. More details related can be seen in Table 5.

Table 5. Why-Why Analysis of Waste

No	Issue	Why 1	Why 2	Why 3	Why 4	Why 5
1	Setting the program, installing molds or fixtures for the process Injection molding	Manual process, and long time	Types of molds or fixtures for the injection molding process vary	Dimensions and types of S/A worm gears vary in the Injection molding process	-	-
2	Setting the program and installing jigs or fixtures on the machine table in the shaft assembly process	The installation process is manual, and long time	Types of molds or fixtures for the shaft assembly process vary	Dimensions and types of S/A worm gears vary in the shaft assembly process	-	-

Based on Table 5, the reasons related to program settings, installation of molds, jigs, and fixtures on the injection molding machine table have been obtained. In addition, it has also been found that the reason for the shaft assembly is due to the varying dimensions and types of gears on the S/A worm shaft. To fix all of that, it is necessary to take action with the 5W+1H method carried out with FGDs between related parties who are experienced in overcoming these problems. The following are the results of the discussion of these problems with 5W+1H which can be seen in Table 6.

Table 6. Analysis of 5W1H of Waste

Factor	What	Why	Where	When	Who	How
Man	The operator does not know the proper and correct installation and setting procedures for molds, jigs, or fixtures	There is no SOP	Injection molding process area and shaft process assembly	Every change in model	Production	Training and making one point lesson on station process
Methods	S/A gear worm products vary	S/A gear worm jigs and molds are different for each model	Shaft assembly process area	Every change in model	Production	Make SOP and list the use of jig or fixtures
Machine	Molds, Jigs, or fixtures in the S/A worm gear production process vary	Dimensions of different S/A worm gears	Injection molding process area and shaft process assembly	Every change in model	Engineering	Create and add programs or fixture auto-change models that can facilitate and speed up each model change process

D. Future VSM

Based on the results of the previous analysis, a future state mapping was made on the production process of the D17D type S/A gear worm which has been root cause analysis with why-why analysis and 5W+1H in FGD. For more details related to the results can be seen in Figure 6.

Based on Figure 6 the injection molding process was improved with a reject tolerance ratio of 23.37% with a cycle time of 88.17 seconds and the shaft assembly process was improved with a reject tolerance ratio of 4.96% with a cycle time of 45.53 seconds. critical for analysis and improvement. In the Injection molding process, improvements made in eliminating waste in the process of installing molds or fixtures as well as setting machine programs are creating and adding auto change model programs/fixtures that can facilitate and speed up each model change process.

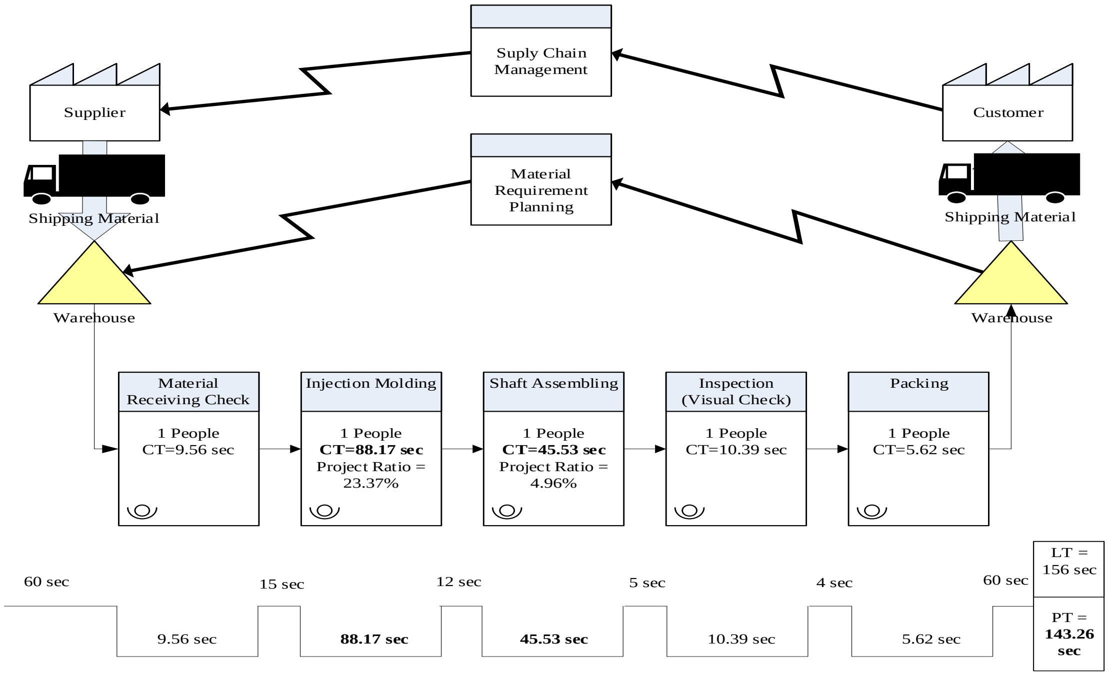

Figure 6. Future State Mapping

The total processing time from the previous injection molding was 120.18 seconds with the process of installing molds or fixtures and setting the previous machine program at 97.90 seconds, it is necessary to design and manufacture programs or fixtures to auto-change the model in this process to achieve the target set in the future state mapping of 66.00 seconds or a decrease of 33.00% from the previous time. Improvements made to each process have an impact on processing time. Some processes are considered reduced because they do not provide added value so that they can be maximized on activities that provide added value. The improvement process resulted in the efficiency of processing time from 194.87 seconds to 143.26 seconds, with changes in processing time reduced by 26.40%.

E. Comparation Result

This section discusses the comparison of the results before improvement and after improvement that has been analyzed through the VSM method. The results of this study indicate that lean manufacturing has a significant effect on the process of reducing process time waste in the production line. The comparison before and after the repair can be seen in Table 7.

Table 7. Comparison of Percentage CSM and FSM

Type of Activity	Current state map		Future state map	
	Time (second)	Percentage (%)	Time (second)	Percentage (%)
Lead time	156.00	44.40%	156.00	52.00%
Process time	194.87	54.60%	143.26	48.00%
Total	350.87	100.00%	299.26	100.00%

Based on Table 7, it can be seen that there was an increase in the entire process time of making S/A D17D type worm gear, which was reduced from 194.87 seconds (CSM) to 143.26 seconds (FSM), with a change in the processing time of 26.40%. Based on Table 7, it can be seen that there was an increase in the entire process time of making S/A D17D type worm gear, which was reduced from 194.87 seconds (CSM) to 143.26 seconds (FSM), with a change in the processing time of 26.40%.

F. Production Result

In this section, the results of the product after improvement of the manufacturing process for the S/A type D17D worm gear. This production amount is obtained from company data based on customer requirements for type D17D S/A gear worms as shown in Figure 7.

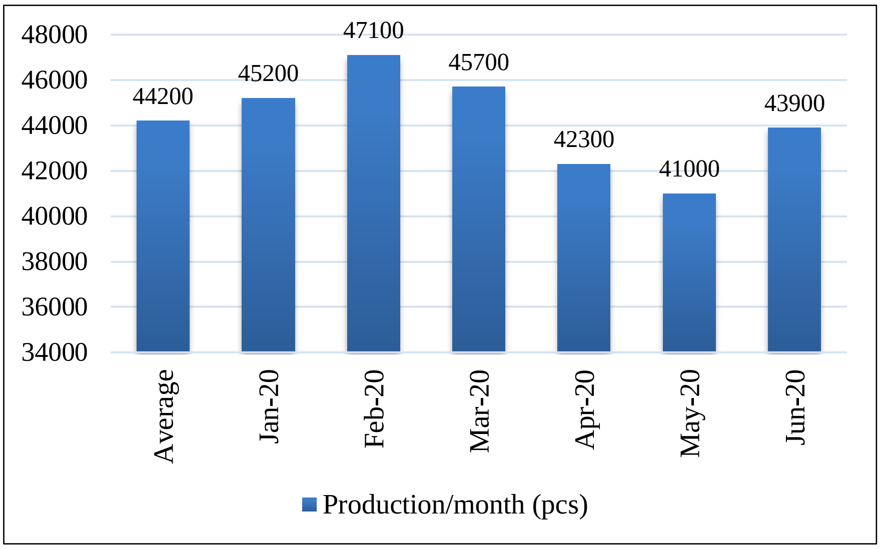

Figure 7. Total production for Gear Worm S/A Type D17D Jan-Jun 2020

Based on Figure 7 the average production for S/A gear worm type D17D is 265,200 pcs per 6 months or an average of 44,200 pcs per month. This means the average production per day is equal to 2,210 units per day (20 working days/month). From Figure 3 the average production is 42,917 pcs per month, so there is an increase in production every month by 1,283 pcs per month. The contribution of this research can reduce the processing time of the S/A D17D type worm gear manufacturing process so that it has an impact on increasing plastic production to meet customer demands.

V. CONCLUSION

This research has identified waste in the production process of S/A gear worms for DC motor components that the low level of production achievement results in a significant difference between production achievement and production targets. This study found the types of waste obtained include setting the program or fixture on the machine, and checking finish goods in the injection molding, however, the types of waste obtained include setting the program on the machine and setting the jig or fixture on the machine in shaft assembly processes. Corrective actions that have been carried out by identifying the causes are carried out using the 5W+1H method and why-why analysis carried out in FGDs to parties related to causes which include man, method, and machine factors.

The results obtained have been able to reduce the processing time of making S/A type D17D worm gear in injection molding from 120.18 seconds to 88.17 seconds or by 32.70% and in the shaft assembly process, the processing time can also be reduced from 49.13 seconds to 45.53 seconds or 37.82%. In total, the entire process time for making S/A type D17D worm gears has been reduced from 194.87 seconds to 143.26 seconds, with the change in processing time reduced by 26.40%.

The implication of this research has been to reduce the processing time of the S/A type D17D worm gear manufacturing process, so actually it has increased production yields which has an impact on fulfilling customer demands. In further research, the researcher suggests integrating the concept of lean manufacturing with green manufacturing so that companies not only benefit from reducing waste but also get efficiency from reducing waste that pollutes the company's environment.

AUTHOR CONTRIBUTIONS

C. Jaqin: Conceptualization, Methodology. **H. Kurnia**: Validation, Sofware. **H. H. Purba**: Writing – review & editing. **T. D. Molle**: Writing – original draft. **S. Aisyah:** Supervision

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