

# Casing Head Part Production Process Improvement Using Lean Manufacturing Approach.

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**Abstract.** PT. ABC is a company engaged in manufacturing industrial machinery and energy, such as designing, producing, and serving systems and products with advanced technology, such as subsea production and processing systems wellheads. There are inefficiency in casing head part production process (delays in starting production activities due to the unavailability of several supporting raw materials and delays in production activities due to late submitting work order information). This study aimed to obtain casing head part production process improvement using lean manufacturing approach. Based on the data collecting, we make Current Value Stream Mapping (VSM), Process Activity Mapping (PAM) for Casing Head Part production process. Then we analysis the waste and causes of the waste using Fishbone Diagram. Based on the analysis, we propose the improvements were including to follow the SOP for repairs of Marking Machine, hold meetings every week regarding the project's status based on the order's delivery date, using shadow boards, inventory tracking spreadsheets, designing WO Boxes, implementing 5S, using Poka-Yoke Design with infrared sensors, also the Inspection Process SOP. Then, we make the Future VSM and Future PAM. The difference between Current and Future of MLT is 44.375 hours.

**Keywords:** lean manufacturing, waste, VSM, MLT.

## 12. Introduction

Oil and natural gas are key industries in the energy market and play an influential role in the global economy as the world's main fuel source. The development of oil and gas drilling in Indonesia has more targets because drilling can be one of the keys to increasing oil and gas production and reserves. The increase in oil and gas production impacts the increase in projects to make wellheads. As the level of drilling projects increases, proper production process is required.

Lean Thinking is a systematic and integrative method that is implemented continuously to minimize or prevent waste or non-value-added processes by carrying out continuous improvement through mapping involving all employees, both from the top management level to the lowest level. The use of lean thinking in production activities is called lean production. Currently, many companies are implementing a lean production approach in order to face business competition in the industrial era 4.0. Industry 4.0 directs companies to become smart factories so that they can reduce the time to respond to customer requests and increase system productivity. The goal is to achieve a smart factory to reduce waiting time and increase productivity in the system [1]. The industry 4.0 concept can be perceived as a strategy to compete in the future. The company is expected to have a high level of efficiency to prepare for the industrial era 4.0.

With the application of lean manufacturing in companies, it will direct mass production practices in companies into a production system that focuses on good quality products to meet customer satisfaction, where anything that does not add value expected by customers will be considered waste. Seven types of waste are the focus of improvement in lean manufacturing: excess production, excess inventory,

inappropriate processing, movement waste, waste due to waiting activities, waste due to defects, and waste due to transportation activities [2].

Lean production is management that focuses the organization on continuously identifying and removing sources of waste so that processes are continuously improved. The term improvement implies that something about a process has changed for the better. Accordingly, the way to transition to lean production is not to do it everywhere and quickly, but to do it carefully, selectively, here and there, through a continuous series of small improvements—kaizen. Kaizens are the principal means through which lean analysis tools (e.g., Value Stream Mapping and 5S) are utilized and lean improvement methods (e.g., setup reduction, preventive maintenance, standard work) are implemented [3].

Lean manufacturing approach is helpful for companies in reducing waste, increasing the value of a product, and improving the quality of products that are likely to appear during production implementation. Meanwhile, lean production is the first and foremost, a system, that is, an integrated series of parts with a clearly defined goal. A central goal of Lean production is to improve profitability by reducing waste[4].

Process activity mapping has its origins in industrial engineering. Industrial engineering comprises a group of techniques that can be used to eliminate from the workplace waste, inconsistencies and irrationalities, and provide high-quality goods and services easily, quickly and in expensively. There are five stages to this general approach: (1) the study of the flow of processes; (2) the identification of waste; (3) a consideration of whether the process can be rearranged in a more efficient sequence; (4) a consideration of a better flow pattern, involving different flow layout or transport routeing; and (5) a consideration of whether everything that is being done at each stage is really necessary and what would happen if superfluous tasks were removed [5].

Lean manufacturing approach is practice organizations from numerous fields can enable. To optimize disk production and minimize or eliminate losses. Based on that, there are several tools and propose specific measures to analyse lean production. Lean production tools include the following: redesign of the work place, visualization, 5S, Poka-Yoke, Single Minute Exchange of Dies (SMED), Total Productive Maintenance (TPM), and standardized work [6]. Poka-Yoke is a Japanese repair strategy for fault checking to prevent defects from occurring during the production process [7]. 5S is a methodology for creating and maintaining a well-organized, clean, highly effective, and high-quality workplace [8].

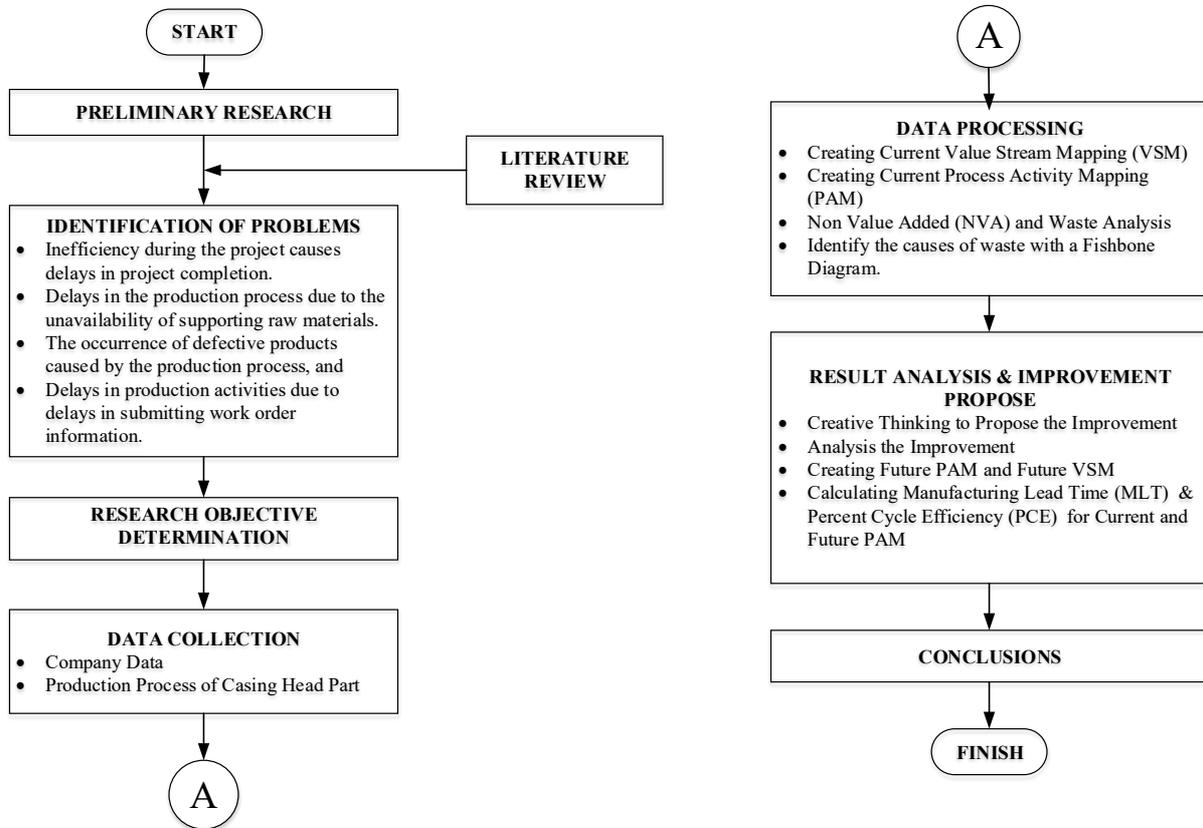
PT. ABC is a manufacturing company that produces offshore, onshore, and underwater construction, project management, engineering, procurement, and energy industry construction products. The form of the resulting product must follow the wishes of consumers with the processing time by the initial agreement. The process of making the casing head is made in the form of a project. Services provided by the company to consumers range from producing products to the installation process in wells.

Throughout production, several problems occurred, including inefficiency because it needed to be more suitable for the company's plans or targets. That was caused by some waste, which could cause delays in order completion, defects found in the finished product, the release of work orders (WO) by operators, and delays in starting production activities due to the unavailability of several supporting raw materials.

This research aims to obtain casing head part production process improvement using lean manufacturing approach based on PT ABC case.

### **13. Methods**

The research methodology describes the steps in systematically implementing the research. The stages carried out in the research can be shown in Figures 1.



**Figure 1.** Research methodology flowchart.

#### 14. Result and Discussion

PT. FMC Santana Petroleum Equipment Indonesia uses the process production of the make-to-order (MTO) and design-to-order (DTO) types. Therefore, the company will only carry out a series of production processes if it gets confirmation of orders originating from consumers or customers. The product that was observed is Part Casing Head. Selection of the Part Casing Head production based on the most requests, and these components are components first produced. The casing head is the lowest part of the wellhead assembly. Casing Head is the place to hang a series of casing in anticipation of leakage on wellheads. Figure 2 is a picture of the casing head. The processes include rough cutting, welding, milling, turning, assembly, hydro & gas test, painting, and inspection. The stainless steel A410 plate is the raw material for casing head products.

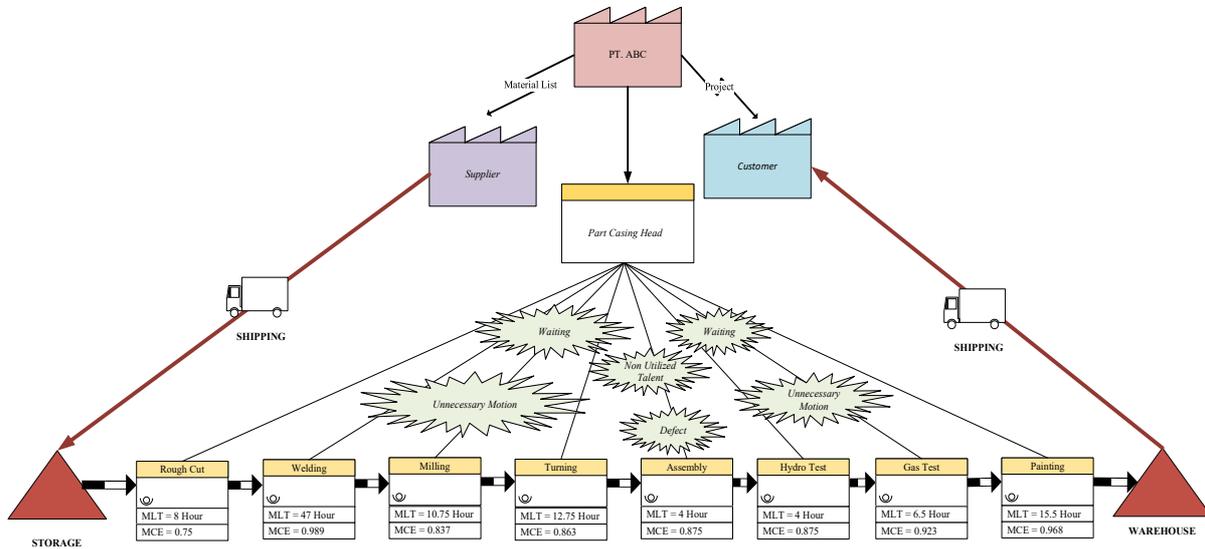


**Figure 2.** Part casing head.

Figure 3 is a Value Stream Mapping for identifying the information related to waste in the production process flow, MLT (Manufacturing Lead Time), and PCE (Percent Cycle Efficiency) values. The following calculations are performed to obtain MLT and PCE values.

$$MLT = Total\ Activity\ Time\ VA, NNVA, NVA \quad (1)$$

$$PCE = \frac{\text{Value Added}}{\text{Manufacturing Lead Time}} \times 100\% \quad (2)$$



**Figure 3.** Current value stream mapping part casing head.

Process activity mapping (PAM) is used to map production processes that occur and can help in analysing the waste in the production process activities.

**Table 1.** Current process activity mapping.

No	Activity	Categories (Hours)			Information (Activity)	Waste Type								Information (Waste)		
		VA	NVA	NNVA		1	2	3	4	5	6	7	8			
1	Receive Purchase Order documents from customers	3.5														
...	...	...	...	...	...											...
12	Check and name the part number			0.5	Inspection needs to be done to determine the quality and labeling of raw materials, but this activity does not add value.				√							Naming the part number using the damaged Marking Machine causes a waiting time.
13	Place raw materials in the Raw Material Storage			0.5	This activity does not add value or change the product's shape, but raw materials must be placed in the warehouse.		√		√	√	√		√			Loss of Work Orders which causes the following processing to be delayed, as well as scratches due to careless movement.
14	Conduct dimensional inspection of raw materials by the Quality Department			0.75	Inspection needs to be done to determine the quality and labeling of raw materials, but this activity does not add value.		√		√	√			√			Loss of Work Orders which causes the following processing to be delayed, as well as corrosion defects not using a protective coating.
15	Place raw materials in the starting machining area			0.5	This activity does not add value or change the product's shape, but raw materials		√		√	√	√		√			Loss of Work Orders which causes the following processing to be delayed, as well as

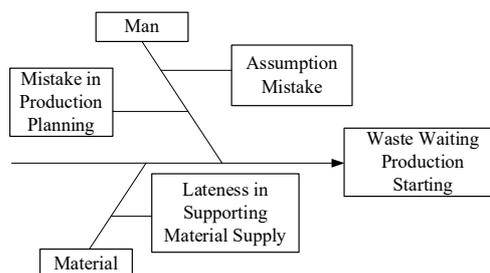
No	Activity	Categories (Hours)			Information (Activity)	Waste Type								Information (Waste)
		VA	NVA	NNVA		1	2	3	4	5	6	7	8	
...	...	...	...	...	...									...
47	Packing with wood			2	must be placed in the starting machining area.									scratches due to careless movement.

<sup>1</sup> Defect ; <sup>2</sup> Overproduction ; <sup>3</sup> Waiting ; <sup>4</sup> Non-Utilized Talent ; <sup>5</sup> Transportation ; <sup>6</sup> Inventory ; <sup>7</sup> Motion ; <sup>8</sup> Extra Processing

**Table 3.** Summary of process activity mapping.

	Description	Activity Amount	Activity Percentage	Time Percentage
<b>Activity Category</b>	Value Added	13	27.66%	27.66%
	Non-Value Added	6	12.77%	12.77%
	Necessary but Non-Value Added	28	59.57%	59.57%
<b>Activity Type</b>	Operation	17	36.17%	39.91%
	Transportation	15	31.91%	54.56%
	Inspection	8	17.02%	2.42%
	Storage	4	8.51%	1.25%
	Delay	3	6.38%	1.87%
	Defect	19	40.43%	21.37%
<b>Waste Type</b>	Overproduction	0	0.00%	0.00%
	Waiting	21	44.68%	23.79%
	Non-Utilized Talent	19	40.43%	21.37%
	Transportation	13	27.66%	10.48%
	Inventory	0	0.00%	0.00%
	Motion	20	42.55%	22.98%
	Extra-Processing	0	0.00%	0.00%

Table 3 show summary table of the mapping carried out with Process Activity Mapping, based on Table 2. There are categories of value-added, non-value-added, and necessary non-value-added activities. Activities that include non-value added are making sales order documents, preparing part order lists, placing part orders, and sending parts. While activities that include necessary non-value added include; receiving work orders, moving parts, and the inspection process. These activities do not add or change the value and form of the product.



**Figure 4.** Fishbone waste waiting production starting.

Figure 4 show the fishbone diagram for waste waiting production starting in identification of waste waiting due to delays in the production process and poor planning that occurs during the production process. Based on the identification of problems that have been done before, it can be proposed improvements to minimize the occurrence of waste as follows in table 4.

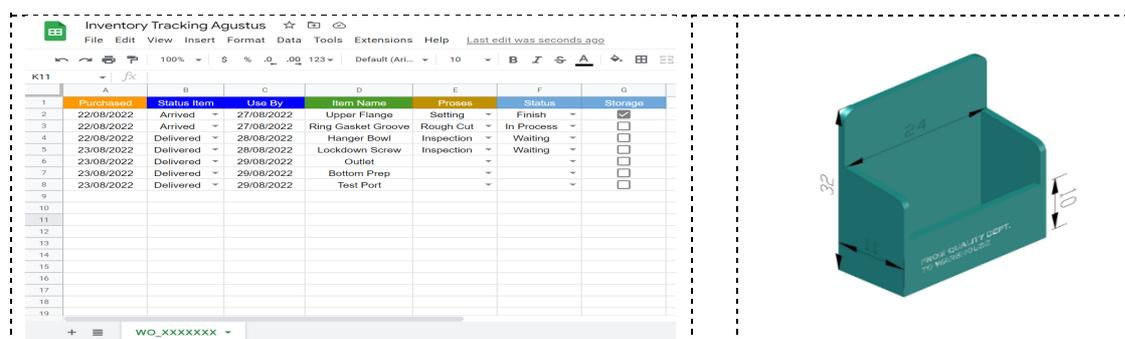
**Table 4.** Improvement for the cause of waste.

Waste	Cause of Waste	Improvement Proposal	Activity	Proposed										
				Level of Difficulty					Possible Applications					
				1	2	3	4	5	1	2	3	4	5	
Waiting	Marking Machine Breakdown	Following the SOP for repairs of Marking Machine	The process of checking and naming the part number			√								√
	Late start of the production process	Hold meetings every week regarding the project's status based on the order's delivery date.	The process of creating a purchase order document				√							
Waiting & Unnecessary Motion	Waiting for the operator to find tools	Using the Visual Management Method in the form of a Shadow Board	Setting machine		√							√		
	Loose and unidentified WO position	Using Inventory Tracking Spreadsheet, WO Box, and Implementing 5S	Change of machining process (Welding, Turning, Milling, Assy, Gas Test, Hydro Test)			√								√
Defect & Non - Utilized Talent	There are scratches on the workpiece	Using the Poka Yoke Design - Sensor to identify objects in the vicinity, and Operator Training	Handling				√					√		
	Corrosion has occurred on the product	Inspection SOP - There is a way to use light oil after the inspection process	After inspection process		√									√

Based on Table 4. A breakdown of the marking machine can be proposed for improvement, following the SOP for repairing a marking machine. Repairs are made to the machine when the engine has been damaged. A lack of periodic machine maintenance and continuous use causes damage to the machine. In handling this maintenance, repairs are carried out when the machine is not functioning, and the machining department approves the repair. The first thing to do is prepare special workers for this maintenance and proceed with routine maintenance activities.

Late start of the production process caused of the late PO (Purchased Order) issuance. It happened cause the planner was error capturing the demand and lack off monitoring outstanding. So, the improvement proposal to overcome this waste is to hold a scheduled meeting every week. In addition, there is a proposed improvement using the visual management method in the form of a shadow board. This is designed to minimize operator errors in returning tools that will be reused.

The following proposal is the creation of an Inventory Tracking Spreadsheet as shown in Figure 5. The system's function is to track the position of the product being worked. An inventory Tracking Spreadsheet is proposed to minimize waste waiting and unnecessary motion.



**Figure 5.** Improvement of inventory tracking spreadsheet.

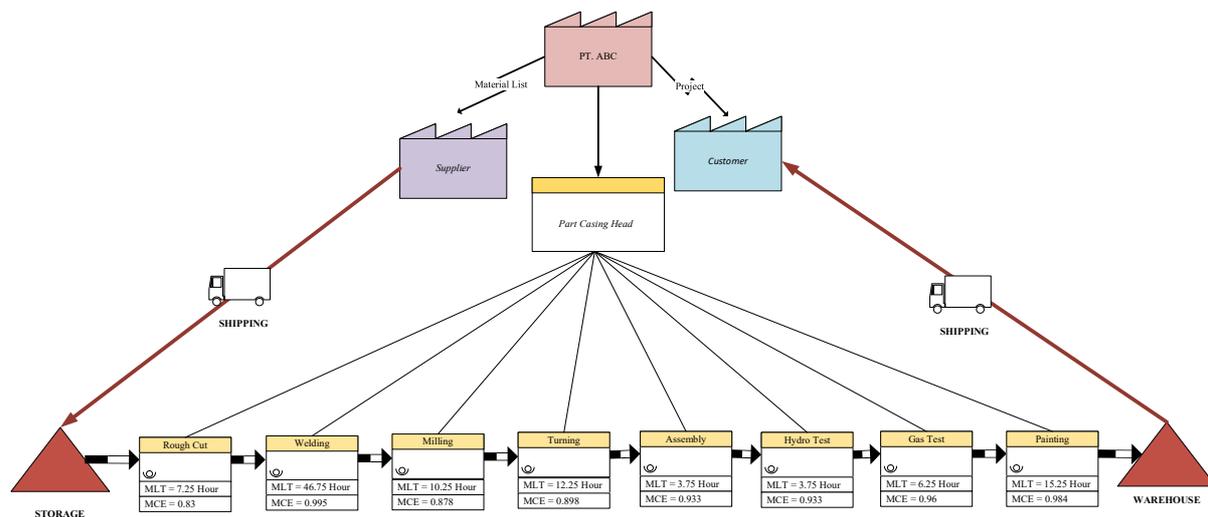
**Figure 6.** Work order box.

The proposed work order (WO) box is applied to changing machining operations. The function of the WO Box is to eliminate operator negligence by using the WO Box. So, the WO file can be placed in its place. The design of the WO Box can overcome the problem of missing WO files so that waste waiting and unnecessary motion do not occur in the process of changing machining operations. Figure 6 is an image of the WO Box specifications that have been designed.

This proposal is designed based on identifying the waste of unnecessary motion and waiting. The existence of a 5S/5R design is media for minimizing waste. The 5S proposals are as follows: (1) Seiri (Sort) is a prohibition to place 1 Work Order (WO) on 1 Machine; (2) Seiton (Set in Order) is the existence of a Visual Board for and WO Box; (3) Seiso (Shine) is to carry out the cleaning process for the scrap resulting from the machining process; (4) Seiketsu (Standardize) is the procurement of routine machine maintenance; (5) Shitsuke (Sustain) is making 5S/5R implementation posters as a reminder so that 5S/5R can run regularly.

The proposed application of infrared sensors is carried out in handling casing head parts to eliminate inappropriate operator activity (human error) using infrared sensor devices so that the handling process can run smoothly, precisely, and accordingly. Infrared sensors can detect objects around the product with a maximum sensor distance limit of 2 to 8 cm, which can be adjusted via the rotation of the sensor. The last improvement is following the SOP for inspection. This proposal was designed based on identifying Corrosion & Non-Utilized Talent Waste Defects. SOP serves as a data reference for the importance of coating with light oil during the inspection process to avoid product defects.

Future State Stream Mapping is a tool for mapping the results obtained from the improvement process. The results of the repair analysis are started by mapping the sub-tasks with value stream mapping, followed by mapping using process activity mapping. The sub-task mapping with future state mapping will be obtained when repairs are made. Figure 7 shows the mapping results with the future state stream mapping part casing head.



**Figure 7.** Future state stream mapping part casing head.

Figures 3 and 7 show a decrease in the MLT value and an increase in the PCE value in each sub-task. It happens due to reduced waste previously identified with the proposed improvements, as in the rough – cut process, with a difference in the MLT value of 0.75 hours and an increase in the PCE value of 0.08%.

Changes that occur with improvements have caused several types of waste to have been reduced, including; defects, waiting, non-utilized talent, and motion. As for transportation waste, it is not possible to implement the proposed improvements soon. All types of activities have decreased in production time. Activities that experience changes include moving products from the warehouse, work stations to returning to the warehouse. Then there are inspection activities and machine settings.

Differences in production time for the operating activities occur in making sales order documents by planners, preparing parts order lists to suppliers, setting sawing machines, setting milling machines, and setting turning machines. Meanwhile, the difference in production time for the type of inspection activity occurs in inspection activities for defects in raw materials by the quality department, checking and naming part numbers, dimension inspection on raw materials by the quality department, and final inspection. And the difference in production time for the type of storage occurs in the activity of placing raw materials in the raw material warehouse, as well as positioning products in the warehouse staging area

**Table 5.** Comparison before and after improvement.

	Before		After		Difference	
<b>VA</b>	120	Hours	120	Hours	0	Hours
<b>NVA</b>	177.75	Hours	140.13	Hours	37.625	Hours
<b>NNVA</b>	23	Hours	16.25	Hours	6.75	Hours
<b>MLT</b>	320.75	Hours	276.38	Hours	44.375	Hours
<b>PCE</b>	37.41%		43.42%		Increase 6.01%	

Table 5 compares before and after the proposed improvements in the Part Casing Head production process. The difference in the total lead time before and after the improvement is 44.375 hours. Meanwhile, the Percent Cycle Efficiency (PCE) value increased by 6.01%.

## 15. Conclusion

Based on the results of research and calculations, the following conclusions are obtained:

- Identification of the waste in this study resulting in waste that occurs, among others, waste waiting, unnecessary motion, defects, and non-utilized talent.
- Proposed improvements are to follow the SOP for repairs of Marking Machine, hold meetings every week regarding the project's status based on the order's delivery date, using the visual management method in the form of a shadow board, using an inventory tracking spreadsheet, WO Box, implementing 5S/5R, Using Poka-Yoke Design in the form of a sensor infrared to identify the presence of objects around it, operator training, and making Inspection SOPs.

By using a lean manufacturing approach, the casing head part production process can be improved by eliminating waste in the activities carried out. There was an increase in production efficiency from 37.41% to 43.42% as well as a decrease in manufacturing production time by 44.375 hours.

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