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Re-design Production Process Using Lean Manufacturing Approach for Pressure Vessel 421 Psi

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Abstract. In order to become more competitive, the terms of improving quality, productivity and efficiency while reducing production costs is a challenge that must be faced by all manufacturing industries. Implementation of lean manufacturing (LM) can be made by doing simple changes to the previous process for future processes. Traditionally, strategies to achieve cost reduction are only made with improvements from the perspective of operational efficiency using LM. This study aims to present an overview of the simplification and trimming workflows that going to re-design the flow process. The objects observed were fabrication process of shell with design pressure 421 Psi. Firstly, mapping the process using current state mapping, identified the highest percentage of non-value added activity (NVA) using process activity mapping (PAM), then minimized and or eliminated with improvements propose to a product design that is analysed using design for manufacturing and assembly (DFMA) approach. From the improvements propose, it was found that manufacturing costs could be reduced until 103 million rupiah and lead time reduced by 13.5 days from 19 days to become 5 days, also a future state map of improvements proposed that have been given.

1. Introduction

Lean principles are described as focusing on people, value driven process view, problem solving, and long term thinking [1] which can be transformed and applied into the application of observed cases [2]. Traditionally, emphasizing lean implementation is only in production process[3] . This is evidenced by the research literature and extensive observations which mostly discuss lean practices [4] and improved performance [5] on production process. The implementation of lean manufacturing in the fabrication industry can be explained related to locus of implementation is any arrangement of events or actions that meet or are determined by certain conditions in an organization, such as shop floor or transactional processes [6] . Lean practices used in the engineering to order industry [7] and extensiveness (relative level of implementation of practices, compared to previous versions) towards the forms adopted in repetitive manufacturing processes [8]. Value stream mapping which is one of the lean methods in order to know the whole process (lead time). Value stream is the main stream of all activities, both value added and non-value added activity needed to obtain a product, including the production flow from raw materials to consumers hands and from design concepts to product launches [9]. The benchmark for lean implementation is using process efficiency measurements. Process efficiency is the percent of cycle time spent on activities that have added value and how much is wasted [10].

For conventional manufacturing, 70% of production costs can be estimated in the design phase [11] efficiency in the design phase. Each product design has its own attributes that produce different levels

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of impact in the overall project life cycle, so that's very important to distinguish which parts of the product life cycle require attention to achieve the best results from the efforts to minimize overall production costs and shorten time product to market [12]. What is not commonly seen in traditional Lean Manufacturing approaches is on the product itself which is limits the focus on the actual process (the causal relationship between part design and production efficiency) [11]. A product developer has the potential effort for reducing costs and time by using tools of certain design decision, so they can design the products for efficient manufacture and assembly [12]. The predictions of future manufacture and assembly problems ensures that the potential result of eliminating waste before the product actually reaches the production line [11].

This research aims the effect of changing the product that capable to restructuring the production process and how to design product provide a shorter process in order to obtain and going to be lean manufacturing (LM). First generate current state mapping then analyze measurement of LM (waste) in actual process before, using process activity mapping. The proposed improvement deliver the new design (using design for manufacturing and assembly approach) for predicting future process production (produce the prediction of future state map and cost estimation). The research object is a family products of pressure vessels (called shells) which was designed according to only customer requirements (421Psi).

2. Methodology

2.1. Literature Study

There are several studies on lean manufacturing and how reduce production time in engineering to order which is the basis and gap in this study. Chauhan & Singh (2012) argues that lean implementation in engineering to order is not very good. This study provides descriptive statistics (mean and standard deviations) of lean manufacturing parameters from the units surveyed [13]Shows that the engineering to order company has implemented lean in terms of "eliminating waste" which reaches the maximum value (0.6748), followed by "continuous improvement" (0.6648), "vertical information system" (0.6398) and "zero defects" (0.6385), this shows that the industry only places emphasis on these fields.

Septiawan & Bekti (2016) identified the root cause of the 11-month delay in the fabrication construction industry despite the fact that the project began on time [14] . Then analysed using a systematic method to find the root cause of the delay in completing the project with the method of Ishikawa / fish bone diagram. After obtaining the main root cause, then it is analysed with the criteria of "5M". This study shows that the strongest delay is caused by human error. Especially in the phase of designing the product is the most crucial thing that can cause the length of time in the production process of the product itself. In addition, in produce drawing that is fit with customer requirements, drawing revisions need to be done, which results in a lot of drawing for one product. This study, provides an analysis that during the production process, many workers do not have the ability to read technical drawings due to inadequate worker skill. The recommendations given are to improve the ability of workers by conducting training, recruiting more professionals, recruiting third parties, or giving penalties if drawings are used late.

Jadhav et al. (2018) explained that the implementation of lean manufacturing in the metal fabrication industry still has non-value added activity (NVA) which causes waste on time and labour costs [7] . Fish bone diagram is used to analyse the root causes of NVA in 5 categories (man, machine, method, material, environment). This study aims to explore the possibility of improving indicators of fabrication processes by eliminating activities in manufacturing processes that do not add value to products as well as providing effective solutions to this problem through lean manufacturing techniques. By applying the principle of lean manufacturing, the welding operation time is drastically reduced, which leads to a reduction in the cycle time of the welding process. Reduction in this cycle time has a significant impact on company productivity. The method proposed to correct the fabrication problem in welding activities is to adopt the automation process and try to combine the activities that

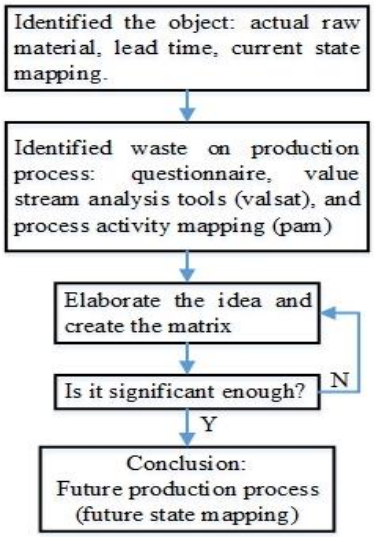
are parallel at one time without affecting the output so as to increase the welding speed. In addition, the proposed method is a material increase in the forecasting method for material availability and providing training to find out the use of automatic welding machines.

The research conducted by K.Sopian (2008) provides a description of the use of design for manufacturing (DFM) methods and design for assembly (DFA) can reduce production time in the engineering to order industry, with pressure vessel as the object observation [15]. This research process changes design to produce shorter fabrication times. The main parameters measured in this study are limited to the reduction in the number of components and the time of fabrication. The pressure vessel part which is the main focus to be designed with the DFA and DFM approach is not the main part of the pressure vessel constituent. But in the functional or complementary part of the pressure vessel. The complementary part of the pressure vessel depends on the operational function of the pressure vessel and there is not always any pressure vessel product.

2.2. Flowchart

Re-design production process using lean manufacturing approach, begins with identification the object, the actual raw material and process then result the current state mapping. From the current state map, it is known the lead time in each process, then identified waste using a questionnaire and obtained the largest waste, which is calculated the percentage value of value added activity (VA), non-value added activity (NVA) and necessary non-value added activity (NNVA).

The conceptual model for this study is given in Figure 1.



Fugure 1. Conceptual model for redesign production process

The first step is identify the objects includes actual raw material needs, actual processing time, activity mapping with current state mapping and actual conditions as the determinants condition for improvement. After identifying the object, then elaborate the idea. Elaborate the idea is process of identifying the difference between actual number of components and costs with the proposed analysis, then a matrix is made to help the designer to decide and choosing the appropriate manufacturing process between the quality function, number of parts, time and production costs. If the results of the analysis of quality functions, number of parts, time and production costs are smaller than actual, then proceed to the next process, that gives a future state mapping from analyzing the prediction for future process.

3. Results and discussion

From the process, the VSM (Value Stream Mapping) is made, which is a data mapping of raw material flow starting from raw material dating and then processed to produce finished goods. VSM makes the Lead time model of each work station widely mapped, but with a low level of detail. The VSM that used in this study called current state mapping, in Fig.2

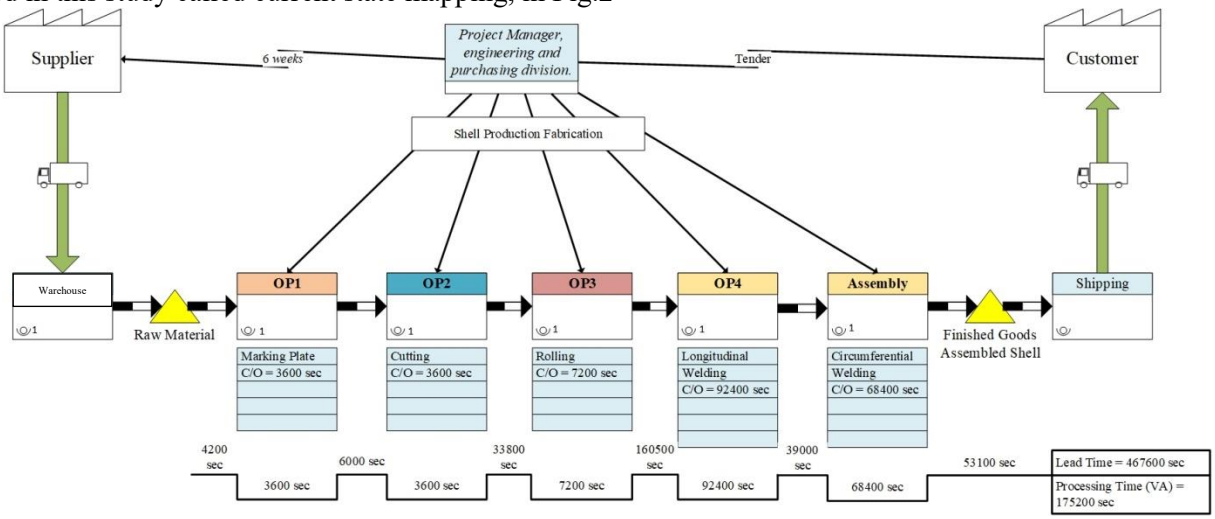


Figure 2. Current state mapping shell fabrication

From Fig.2 there is a difference between the lead time and processing time which can be indicated as a waste. To know more about what types of waste in those process, we used a ranking from the questionnaire. The three biggest wastes produced are unnecessary motion, waiting and defects. After knowing the type of waste, then a selection of tools is carried, to find out the percentage of waste in each workstation activity. The tools used are Process Activity Mapping (PAM). These tools is not only mapping all of the activities in detail, but also consider the efficiency of process rearrangements, consider the better flow and consider different transportation layouts and routes

Based on the PAM it is known that the largest percentage of NVA (Non Value Added) is 51.31% in longitudinal welding activities. The solution to the reduction in NVA percentage is by using a Tubular Rolled Plate (TRP). TRP is useful to reduce longitudinal welding which has an impact on reducing time and production costs as much as. The following is a comparison of TRP Analysis with the actual process. To compare the actual and the future process is presented in the Table 1.

Table 1. comparison between actual and future process (source: manufacturing data)

Category	Classification	Actual process	Future process	Value
Parts / components	Raw Material (quantity)	4	3	1
	Method / Processing (days)	19	5.5	13.5
	Raw Material (price)	IDR, 233,592,000	IDR, 255,879,000	(-) IDR, 22,287,000
Cost	Labour	IDR, 146,281,342	IDR, 42,894,384	IDR, 103,386,958
	Equipment / tools (filler metal)	IDR, 2,738,339	IDR 176,020	IDR, 2,562,319
Waste	Unnecessary Motion	4	3	1
	Waiting	3.5	1.3	2.2

Using TRP is minimize and trimming the production process, because the activity before longitudinal welding was removed so that, produce a work flow (future state mapping) as Fig.3

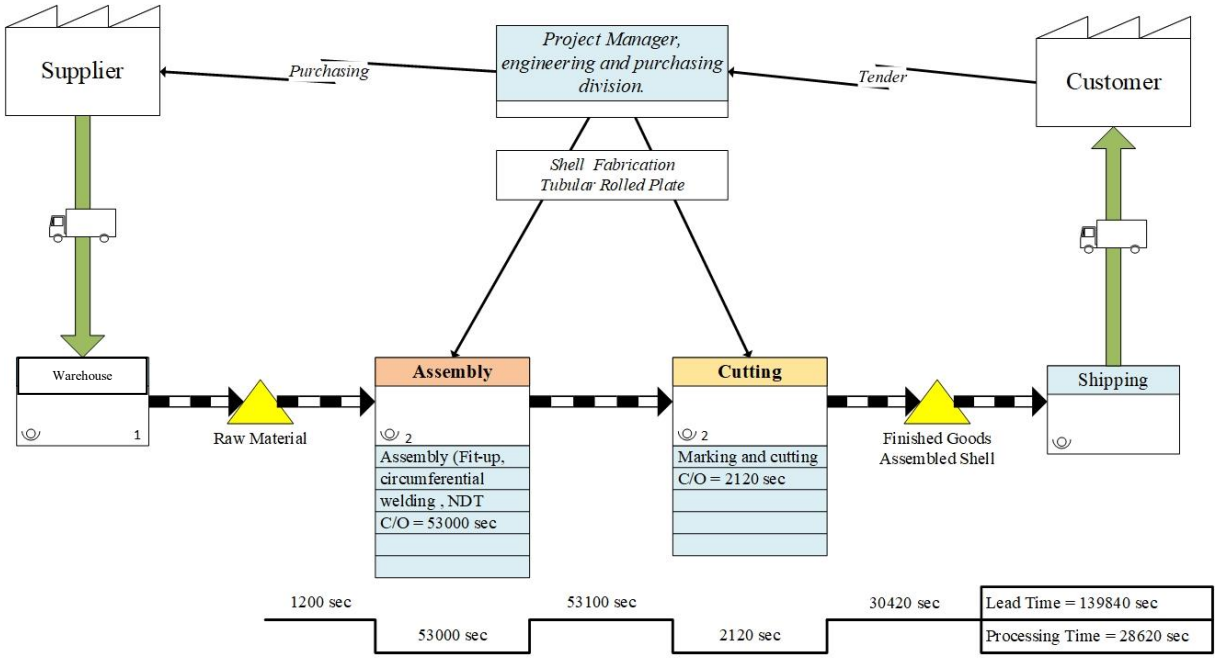


Figure 3. Future state mapping using improvement idea

4. Conclusion

The shell fabrication stage consists of taking material to the supplier, transferring material to the workshop, then proceeding in the form of marking plates, cutting and edge preparation, rolling, welding and assembly. Based on the tools, namely PAM, there are 51.31% waste or non-value added in longitudinal welding (from the calculation of overall activities in the longitudinal welding), the solution to reduce this waste is Tubular Rolled Plate (TRP). TRP is a plate that has been carried out in a rolling process in accordance with the desired diameter but has not been joined (using weld process) between sides. TRP cuts shell manufacturing activities into two important things, assembly and cutting so that the manufacturing cost can be reduced until 103 million and lead time reduced by 13.5 days.

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