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Analysis of Production Process to Improve Lead Time and Productivity in Fabrication by using Lean Methodology. Case Study in Turbine Component Manufacture Company

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***Abstract*: Lean methodology is an efficient way to identifying and eliminating waste through incessant improvement. The purpose of this study is to reduce lead time and increase the productivity in fabrication case study in Turbine Component Manufacture Company with analyzing the process using lean methodology. The study consists of three phase, Define, Kaizen and Realization. From the collected data in the define phase it shows the Current Value Stream Map and identify waste in the process and analysing the spaghetti diagram of worker activity. Benchmarking process with the worker help to find the root caused analyse and create improvement idea in the Kaizen phase. In the Kaizen phase all the improvement plan were realized and draw the new process map after improving the process. Before and after implementation of the improvement the data shows that significantly improve and reduce the process time in Fabrication. This lean approach is very helpful tool for improving productivity, reducing lead time and inventory.**

***Keywords*: Lean, Waste, Value Stream Map, Kaizen.**

1. Introduction

To increase competitive advantage in an increasingly global market, lean manufacturing is a performance-based used in manufacturing organizations. Nowadays lean methodology is applied in many sectors including manufacturing, automotive, electronics industry, and others industry that adopt lean methodology.

To survive on tight competition, a company must be able to provide products accordingly the desires of the consumers, with the categories appropriate price, on time delivery, and quality. For that an effort is needed to improve product quality with knowing the problems in line production then look for cause occurrence. Besides, there are many methods for increase productivity, through the quality improvement or by evaluate employee performance (Wirani, Muri, Gandara, & Ikatrinasari, 2018). In the production processes there are many factors that influence the results of the process, so the process does not get the results as expected. Often the processing time is longer than the available time this causes a lot of losses for the company. This makes the company owners try to improve the process, which is to analyses of the process and make improvements through Lean Methodology. There is a little disagreement that global competition appears the require to adoption of some new methods such as lean manufacturing to increase productivity and quality (Vacanti & Marietta, 2010).

In the turbine component manufacture company, placed in Banten Province, one of the biggest steel structure company in Indonesia is using lean methodology to improve productivity and lead time in the production process. They focus in the manufacturing process to have more efficient and effective due to some of their process still produce defects and waste.

2. Literature Review

A. Lean Manufacturing

According to Hines and Rich in Vinodh et al., (2013) Lean Manufacturing is based on the fundamental goals of Toyota production system (TPS) which is aimed at continuously minimizing waste to maximize flow. According to TPS, the seven most common wastes are overproduction, waiting, transport, inappropriate processing, unnecessary inventory, waste of motion and defects. Kaizen method is one of the proposed improvement work in accordance with the current company conditions to be implemented by focusing its activities on improving the work system and also the involvement of management to improve the quality of the resulting product Ikatrinasari et al., (2018).

Based on Womack in Kumar et al., (2017) It follows umbrella concept which focuses on the process improvement by eliminating waste in the process; thus, it provides a base for lean manufacturing that directed toward the achievement of continuous improvement. It is referred as the key building block of lean thinking.

According to Womack in (Kovács, 2012) Lean thinking is the antidote of the waste. There are 5 Lean principles:

- Specify Value. Value can be defined only by the ultimate customer. Value is distorted by pre-existing organizations, especially engineers and experts. They add complexity of no interest to the customer.
- Identify the Value Stream. The Value Stream is all the

actions needed to bring the product to the customer. If the melter, forger, machiner, and assembler never talk, duplicate steps will exist.
- Flow. Make the value-creating steps flow. Eliminate departments that execute a single task process on large batches.
- Pull. Let the customer pull the product from you. Sell, one. Make one.
- Pursue Perfection. There is no end to the process of reducing time, space, cost and mistakes.

B. Lean Manufacturing

Waste is defined as any activity that does not add value from the customer's perspective. It is interesting to note that the "wastes" typically targeted by environmental management agencies such as non-product geo output and raw material wastes are not explicitly included in the list of manufacturing wastes that lean practitioners routinely target. Mehta *et al.*, (2012) classify eight types of waste by lean methods as shown in Table 1.

Table 1
Eight types of waste

Type Waste	Definition
Defects	Production of off-specification products, components or service that result in scrap, rework, replacement production, inspection, and/or defective materials
Waiting	Delays associated with stock-outs, lot processing delays, equipment downtime, capacity bottlenecks
Unnecessary Processing	Process steps that are not required to produce the product
Overproduction	Manufacturing items for which there are no orders
Movement tran-sporting long distances	Human motions that are unnecessary or straining, and work-in-process (WIP)
Inventory	Excess raw material, WIP, or finished goods
Unused Employee Creativity	Failure to tap employees for process improvement suggestions
Complexity	More parts, process steps, or time than necessary to meet customer needs

The word "waste", or "Muda" in Japanese, refers to any activity which absorbs resources but adds no value from the point of view of the customer referred to Biggart & Gargeya in Cuatrecasas-Arbós et al., (2015).

C. Value Stream Mapping

Hines described in Vinodh et al., (2015) the application of a new variant of process benchmarking called VSM to the development of a supplier network around a prominent distributor of electronic, electrical and mechanical components. Seth et al. In Vinodh et al., (2015) have identified and addressed various wastes in the supply chain of the edible cottonseed oil industry (specifically the processing side) using a VSM approach to improve productivity and capacity utilization in the Indian context. Wastes are then individually attacked to reduce or eliminate them from the system. Suggestions to make the whole chain more productive has been generalized and replicated in the context of other developing countries.

D. Kaizen

According to Karkoszka and Szewieczet in (Singh, 2015), Kaizen (Kai – do, change, Zen – well) is a kind of thinking and management, it is a philosophy being used not only in management field but also in the everyday life in Japan. It means gradual and continuous progress, increase of value, intensification, and improvement. In full Kaizen, training has focused on both philosophical and cultural concepts and is based on the belief that the development of an individual's skill benefits both the company and that individual, and that people constantly achieve self-improvement.

Kaizen method is one of the proposed improvement work in accordance with the current company conditions to be implemented by focusing its activities on improving the work system and also the involvement of management to improve the quality of the resulting product (Darmawan et al., 2018).

Base on Setyaningsih & Putri (2015), Kaizen technique assumed to be a practical technique and it requires low cost. Every small step is counted for a single improvement and do not wait until big, just do it.

E. Lean Ideology

Hines described in Vinodh et al., (2015) the application of a new variant of process benchmarking called VSM to the development of a supplier network around a prominent distributor.

According to Kant et al., (2014), some of the vital features associated with lean ideology are as follows:

- Pull production: The production flow should be driven by demand from downstream means each workstation produces only what is needed by the subsequent workstation, thus eliminating overproduction.
- Takt: Takt is the rate or rhythm at which work progresses through the production line. It is calculated by dividing available production time by daily demand.
- Continuous flow: The production flow should be continuous without interruption and waiting. The ideal batch size in this type of manufacturing system is one.

3. Methodology

Case study research methodology was used. A single case study was chosen because of the exploratory nature of the study. Researchers were involved in the planning, preparation and execution of the Kaizen workshop. In this study research process steps were made as shown in Figure 1 with the aim that the research can go according to plan and get the results as expected.

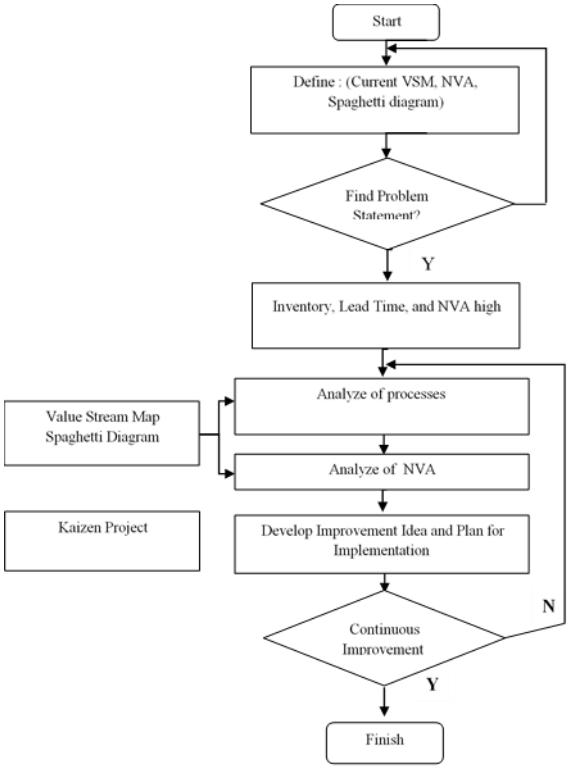


Fig. 1. Research steps of improve lead time and productivity

4. Case of Study

Case study was conduct in turbine component product factory where the production process is one of the parts that incur the big costs, therefore each process carried out must be optimal and without any obstacles. In the Fabrication division in this company productivity was an issue due to production process time were longer than standard time and caused a lot of inventory and disturbing production line. As in Figure 2 process of fitting and welding in the fabrication process of turbine components requires a longer time than takt time (available time): Fitting and welding takt time: 3 days, actual time 4 days. So that there will be a delay in the next process which will affect the timely and additional costs for accelerating the process.

In the Figure 3 shows that for fitting and welding process actual hours are higher than baseline hours, mean that those 2 processes are not efficient and took more time to proceed. The aim of this research is to analyse of the process in fabrication (fitting and welding process) and find the improvement idea through lean methodology. Following are steps to start the lean project:

1. Define current state map.
2. Identify NVA in current state map.
3. Define spaghetti diagram.
4. Improvement idea.
5. New process map.
6. Kaizen.

A good understanding of the production process is essential for the elaboration of the current map, as well as for further diagnosis and improvement proposals. Therefore, visits were made to the company, where the operations were observed (Ferreira, 2013). Current State Map is help to see the complete process and identify the non-value added process that can be eliminated. As shown in Figure. 4.

A lot of inventory between process is disturbing the flow of the process, it is important to keep the takt time and flow of the material between processes are in the same move. Identify the NVA step on current state map, that important to consider only the value add step on the process. In the three focus process in this research found the NVA activities that done inside the process, please see in Table 2.

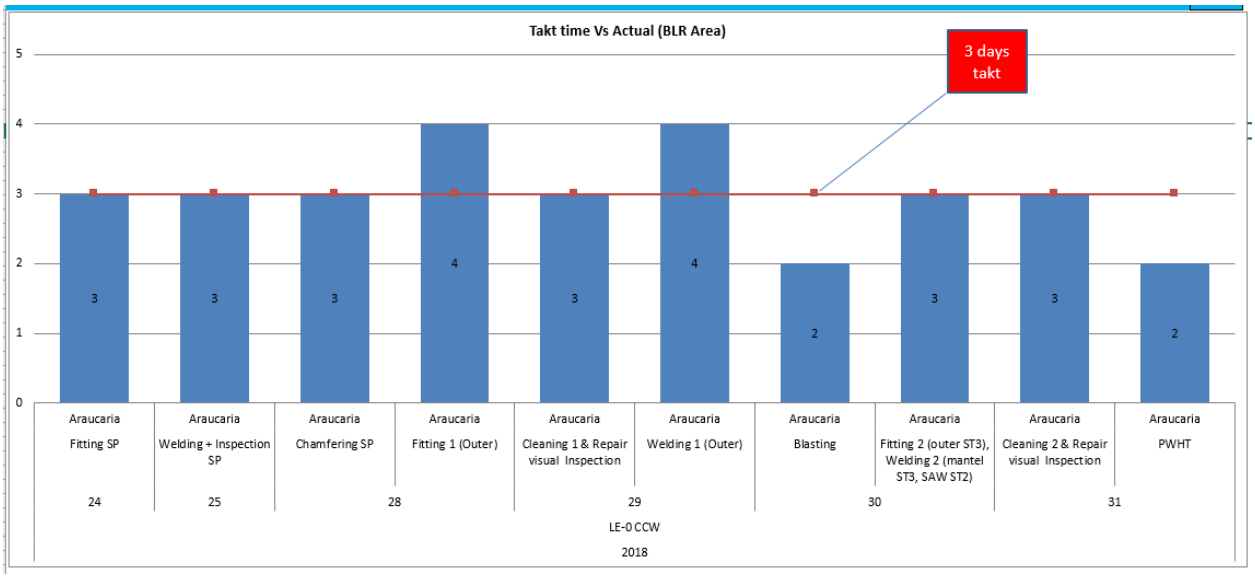
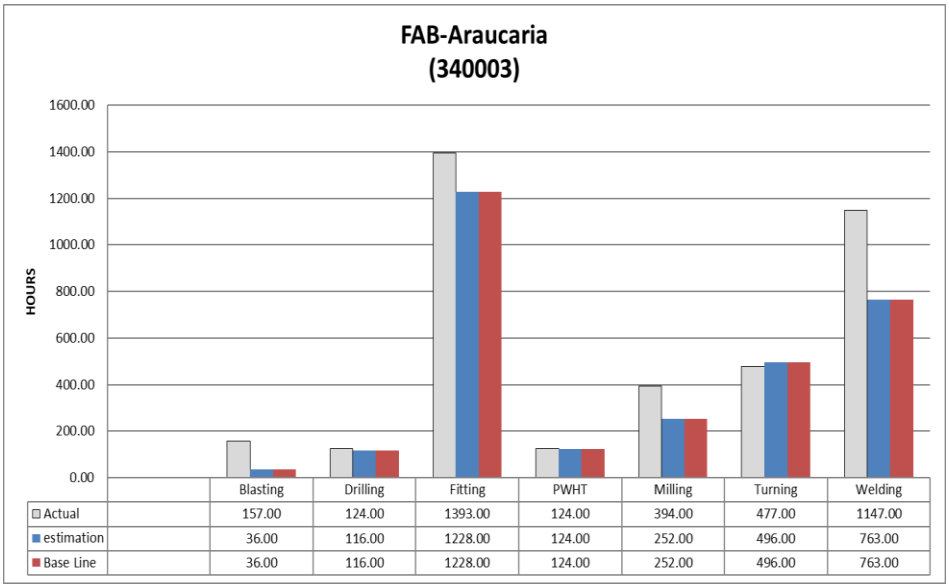


Fig. 2. Takt time vs. actual time in blade ring fabrication



	Blasting	Drilling	Fitting	PWHT	Milling	Turning	Welding
Actual	157.00	124.00	1393.00	124.00	394.00	477.00	1147.00
estimation	36.00	116.00	1228.00	124.00	252.00	496.00	763.00
Base Line	36.00	116.00	1228.00	124.00	252.00	496.00	763.00

Fig. 3. Baseline hours vs. Actual hours for Araucaria fabrication process

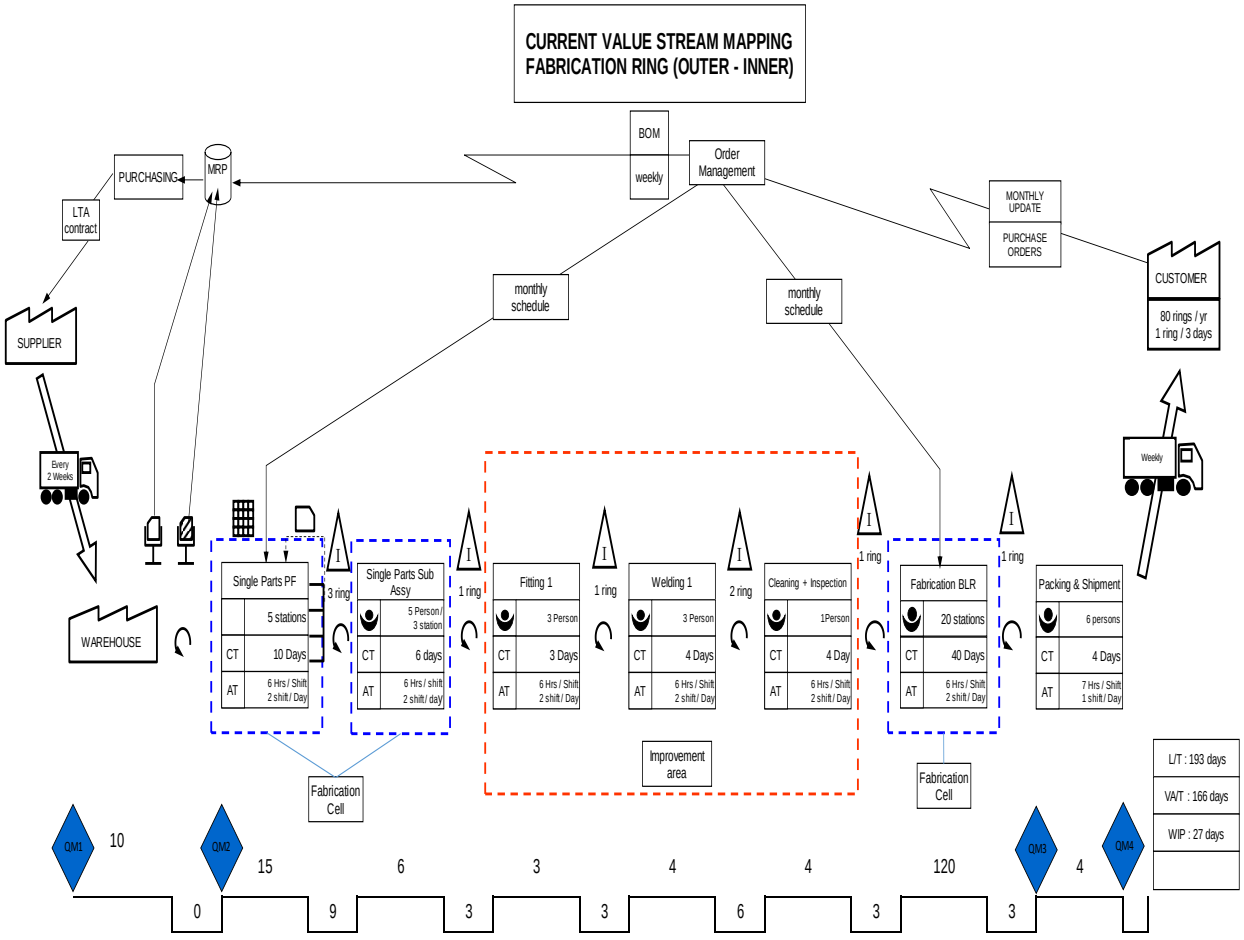


Fig. 4. Current State Map of Fabrication Outer – Inner ring

Table 2
NVA on current state map of Fabrication Outer-Inner ring

No.	Activities	VA	NVA	NVA Needed	Remarks
1	Ordering parts from WH		√		Improve
2	Collecting parts		√		Eliminate
3	Tool preparation		√		Improve
4	Cleaning working area		√		Improve
5	Marking in the working table		√	√	
6	Jig and fixture preparation		√		Improve
7	Assembly parts	√			
8	Self check		√	√	
9	Send component for welding		√	√	
10	Welding	√			
11	Cleaning and repair visual		√	√	Improve
12	Dimensional Check		√	√	

Source: Company Data (2018)

Table 3
Improvement list of Fabrication Process Outer-Inner ring

No	Topic	Improvement Idea	Remarks
1	Improve ordering parts from warehouse	Provided material flow for single parts	Standard for material flow already provided
2	Collecting parts	WH only send parts needed	Implemented
3	Tool preparation	Improving tools storage through 5S implementation and create check list	5S implemented
4	Cleaning working area	5S implementation	5S implemented
5	Jig and fixture preparation	Manage minimal stock and system	Standard jig and fixture available
6	Unbalance process due to less manpower	Add one man power and improve process	
7	Cleaning and repair visual	Improve process	Need deep analyse

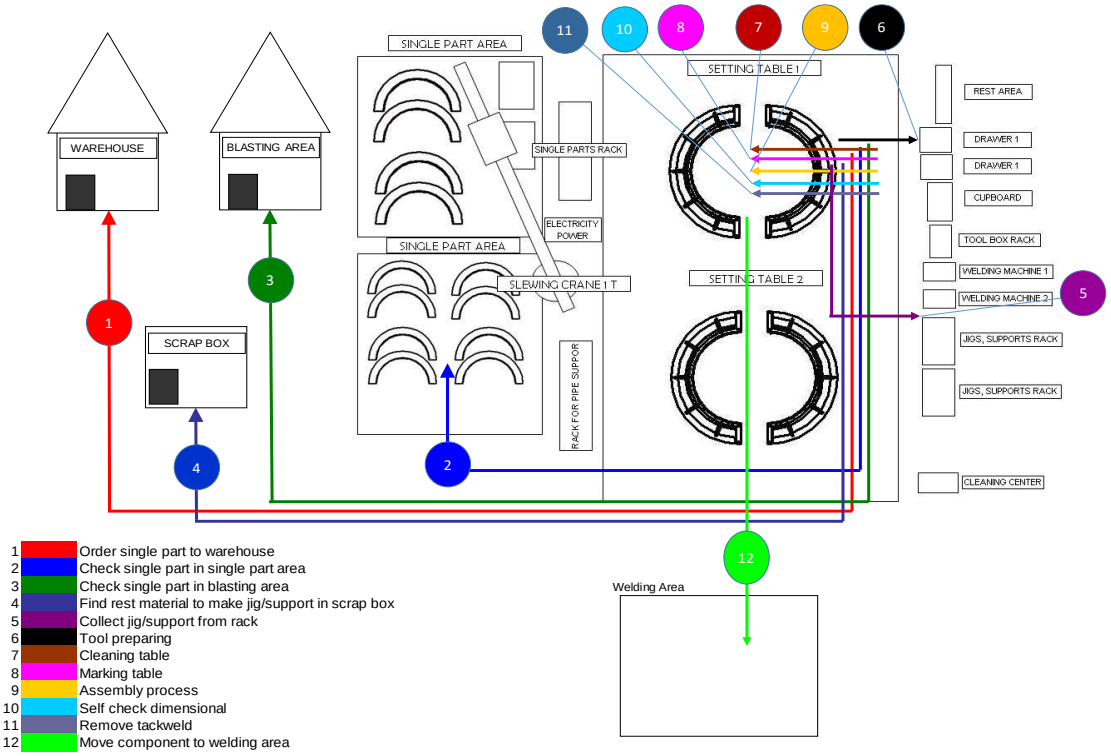


Fig. 5. Spaghetti Diagram Current Process of Fabrication Outer-Inner ring

Spaghetti diagram in Figure 5 shows the movement of worker during the process, analyse the spaghetti diagram from the movement waste and improve the lay out of the tools, material and equipment storage to have more efficient process.

Improvement idea was held with the team in fabrication and some improvement were done using the kaizen project, following the results as shown in Table 3.

Review of the current spaghetti diagram and found some of the activities of the worker that not efficient and as a non-value add activity. The result of reviewing spaghetti diagram is removing some NVA activities as seen in the new Spaghetti diagram and new Value Stream Map on the Fig. 6 and Fig. 7.

From the data in the new VSM after implementing all the improvement idea lead time improve from 193 days to 176 days (reduce 9%) and inventory also reduce from 27 days to 12 days (55%). All the improvement that already implemented such as 5S, create standard flow, standard jig and fixture and also using minimum quantity storage. The employees use a kaizen tool to study the idea and to make sure how the ideas are effective.

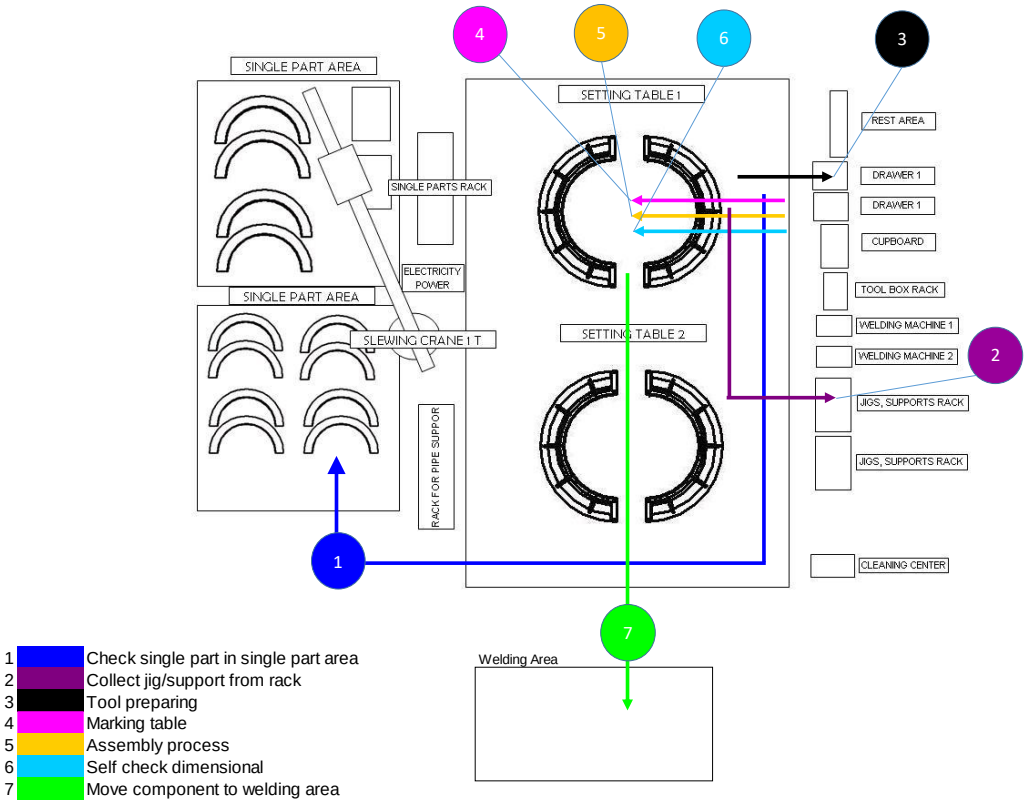


Fig. 6. Spaghetti Diagram New Process of Fabrication Outer-Inner ring

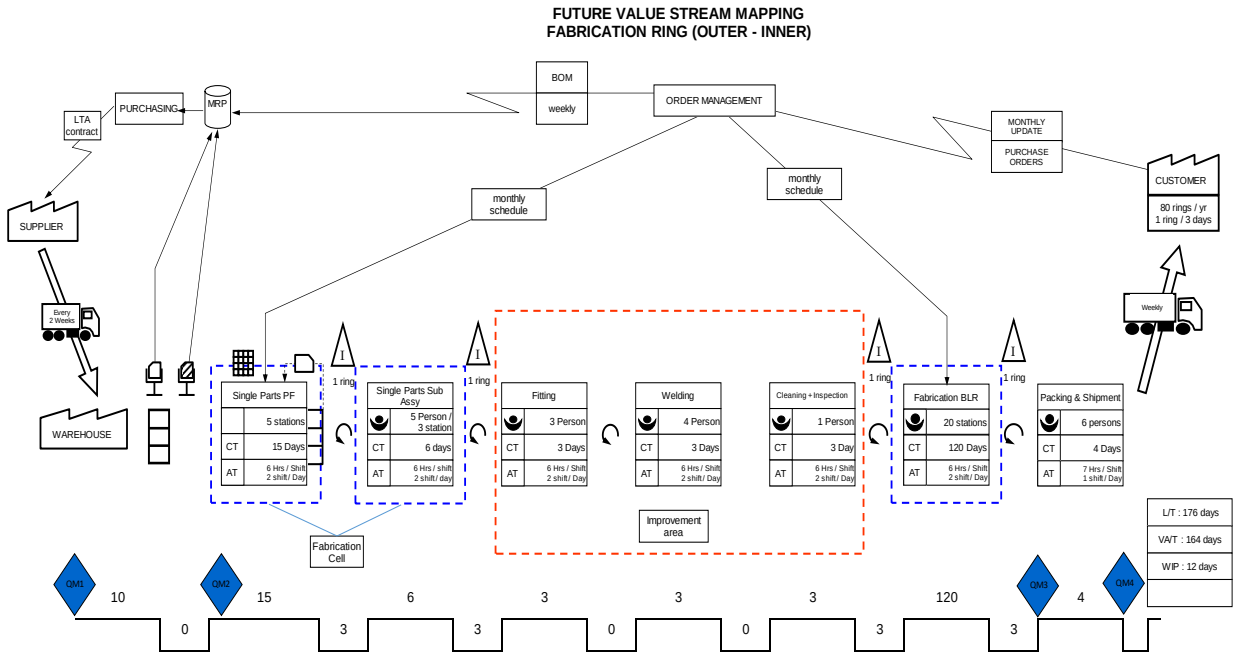


Fig. 7. Future Value Stream Mapping of Fabrication Process Outer-Inner ring

5. Conclusion

A. Lesson Learned

Lesson learned is important for the stabilized the process, it help the company to avoid same mistake happen in the future and to keep the process in a good way.

What went well:

- This was a good project because it has a lot of impact to LEAN program in the company specially in Blade Ring Manufacturing, for improving the process and lead time and makes customer happy.
- This was an interesting project because it has many room for improvement and also challenging for the company for implementing LEAN system in next project.

What could be better next time:

- In this research is limited to one product line, the company would be able to improve all their product line such as Casing, Condenser, and Combustion Chamber Manufacturing lines with using same methodology.

B. Summary

This research summarizes the advantages of the lean philosophy in manufacturing organizations to increase competitive advantage. The author defines the most typical wastes and emphasizes the importance of application of lean manufacturing, lean techniques and tools. Main steps of a lean project completed in an industrial environment were described generally and finally a case study was presented.

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