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INCREASING PRODUCTION CAPACITY OF RACK STEERING LINE AT PT.ABC USING LEAN SIX SIGMA METHODOLOGY

FarhanHarasta Fadruzil[1], Gatot Yudoko[2], and Liane Okdinawati[3]
[1](*School of Business and Management, InstitutTeknologi Bandung, Bandung*)
[2](*School of Business and Management, InstitutTeknologi Bandung, Bandung*)
[3](*School of Business and Management, InstitutTeknologi Bandung, Bandung*)

ABSTRACT: *The economy and population in a country are growingpositively, the need for vehicles has alsoincreased, and the need for companies for vehicles has alsoincreased. PT ABC as one of the leadingsteeringgearassy supplier for PT XYZ cars alsoaffected by this condition. This condition certainly has a positive impact on company revenues, but whatis certain isthat the production capacity must besufficient to meetthisdemand. The normal production capacity of 744pcs/dayis not able to fulfill the demand in full, sothereisovertimewhich has an impact on overtimecost for the company. The purpose of thisstudyis to increase production capacityagainst the ever-increasingdemand and minimizeovertimecost in the COVID-19 pandemicTheprinciple of Lean Six Sigma waschosen as aproblemsolvingmethod, DMAIC waschosen as a Six Sigma tool and VSM as a Lean tool.Impeovements made to increase production capacity are increasing cycle time in the rack steering line by minimizingwaste on machine time. The results of thisresearchis cycle time from 1.1 minutes to 1.0 minutes due to machine improvement, production capacityincreased to 818pcs/day, and overtimecostdecreased.*

KEYWORDS– *Cycle time, DMAIC, Lean Six Sigma, VSM, Production capacity*

I. INTRODUCTION

The demand for vehicles constantly increasing every month and usually has a new model every year to make a differentiation for cars class and type for the customer to choose from. The new model has a purpose so that customer can constantly be refreshed with new choices, and usually, cars manufacturer makes cars in every category that have a significant market share so that they can dominate the market. This condition has an impact on PT. ABC that the request for component production from PT. XYZ is increasing.

PT. ABC is established to reach the company vision and become stronger and trusted to support PT.XYZ is one of the biggest car manufacturers in Indonesia. This company has a contribution to producing a good product, one of it is the steering gear system.PT.XYZ always gives forecasts from an extensive range to a small range. The meaning of large range is forecasting for the next four years, the medium range is for the next one year, following one month until the smallest range is for every week forecasting.

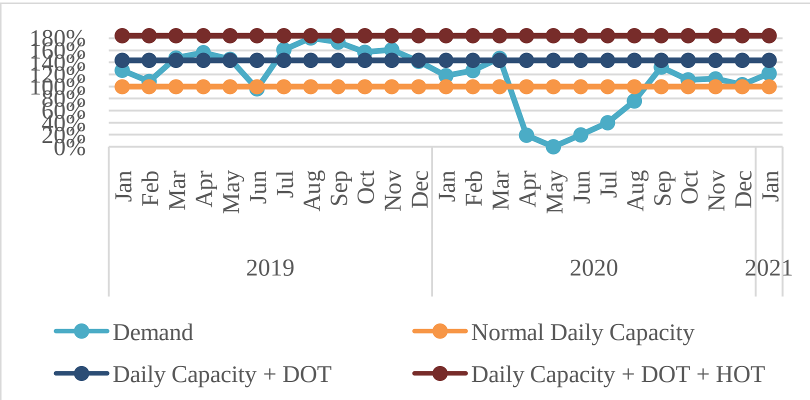

Figure 1. Diagram Demand and Production Capacity Rack Steering in PT. ABC (2019-2021)

Fig 1. We can see that that there is a phase where normal capacity cannot meet customer demand or it is known as “lack condition”. Normal daily capacity is on two shift production per day without Daily Over Time (DOT) and Holiday Over Time (HOT). The existence of overtime (DOT and HOT) has a positive impact in the form of fulfilling demand, but has a negative impact on company costs. PT ABC must prepare to decrease the cycle time in rack steering line from every aspect that is possible so the production capacity can be increase and fulfil the customer demand.

Rack Steering consist of 3 posts of the production line, Process cycle time in every post creates cycle time to process a different product; 1st post needs a process cycle time of 1.1 minutes, induction post 0.77 minutes, and 2nd post 1.1 minutes. Cycle time depends on the total of the machine, handling, and walking manpower that has the longest time in the process. So that the cycle time can be reduced in the rack steering line so that production capacity increases and has an impact on reducing overtime costs.

II. LITERATURE REVIEW

2.1. Lean Six Sigma

Lean Six Sigma is a combination of the Six Sigma and Lean Manufacturing methods. Lean will focus on the waste that occurs during the production process and the Six Sigma phase of undergoing the repair process. The improvement process phase according to the conditions in the company is carried out with the help of the DMAIC methodology.LSS (Lean Six Sigma) can be described as a methodology that focuses on the elimination of waste and variation, following the DMAIC structure, to achieve customer satisfaction with regards to quality, delivery and cost. It focuses on improving processes, satisfying customers and achieving better financial results for the business (Salah, Rahim, &Carretero, 2010). The objectives of Lean Six Sigma are to rapidly improve customer satisfaction and quality, increase process speed and reduce costs. It is typically applied in manufacturing using DMAIC (Define, Measure, Analyze, Improve, and Control) phase to improve product manufacturing processes (Cheng & Chang, 2012).

Six Sigma is a business improvement approach that seeks to find and eliminate causes of defects or mistakes in business processes by focusing on process outputs that are critical in the eyes of customers. Six Sigma principles can be used to shift the process average, help create robust products and processes and reduce excessive variation in processes which lead to poor quality (Shah, Chandrasekaran, & Linderman, 2008).

Lean Manufacturing (LM), a manufacturing system and philosophy, was originally developed by Toyota, Japan and is now widely practiced by many manufacturers throughout the world. Lean manufacturing is a systematic approach to identifying and reducing waste (non value-added activities) through continuous improvement by flowing the product at the pull of the customer in pursuit of perfection (Dixit, Dave, & Singh, 2015).

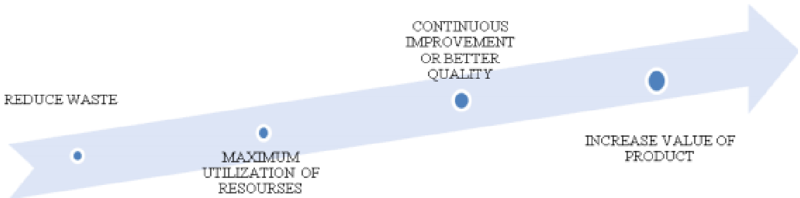

Figure 2. Objectives of Lean Manufacturing
Source: (Dixit, Dave, & Singh, 2015)

2.2. Cycle Time

Cycle time consists of four types of time: Processing time, moving time, waiting time, and inspection time. Only processing time is the time used to carry out “Value- Added Activities” which means activities that generate value for customers. The other three times (moving time, waiting/storage time, and inspection time) are times used to carry out “Non-Value Added Activities” which means activities that do not add value to the customer(Mulyadi, 2007).

III. RESEARCH METHODS

Research Methodology is the science of studying how research is done scientifically. A way to systematically solve the research problem by logically adopting various steps. The methodology helps to understand not only the products of scientific inquiry but the process itself (Patel & Patel, 2019). This concept of research flow is as follows:

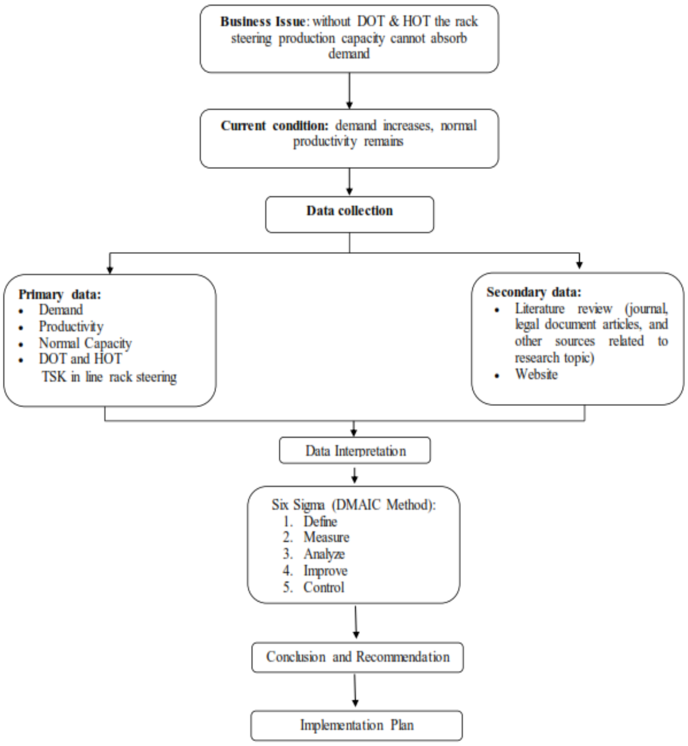

Figure 3. Flowchart of methodology

Based on Fig 4. We can know that the research is triggered by the company's condition where the demand is increasing, and the capacity of production only can fulfil it by DOT and HOT. To do the research, data collection is done using primary and secondary data; primary data tend to be internal data from the company, secondary data is from external resources as supporting and reference data to be analysed. Data collection was done quantitative and qualitative. The data collection process was carried out using *Genba*/field observation, interview, and meeting. Quantitative data obtained are labour workload, demand, cycle time, and production capacity. Qualitative data were obtained based on discussions with the PT.ABC. The data used as a consideration to determine the root cause of the problem.

In this research, we use the Lean Six Sigma method, where the root cause analysis is using DMAIC methodology and combine with lean analysis to minimize waste. The DMAIC method helps to determine root cause, fix, and control.DMAIC stages, among others:

3.1. Define Phase

The first DMAIC phase, in which a project is defined relative to business benefits and customer (Martin, 2008).PT.XYZ is the main customer of PT.ABC, so its role is essential for business continuity. The demand from the customer (PT.XYZ) divided into several categories are 5 years forecasting (*Nenkei*), Annual forecasting (*Nenkei*), Monthly Delivery Forecast Order (MDFO), and Actual daily demand.Determine the critical process within the manufacturing issues or processes using tools SIPOC.

SIPOC diagram helps rack steering problems in terms of suppliers, input, processes, output, and customer. PT.XYZ as a supplier rack steering material in the form of solid iron (S45C) input, a material that has arrived at PT.ABC will go through a process starting from OP-10 to OP-140 by the stages determined by PT.ABC. The output of this process is Rack Steering finish machining, Test & Inspection records, and Production records. And the customer is the Assembly steering line, Site quality time, and Site production, team. The results of the SIPOC diagram are used as an essential reference in carrying out the next step of DMAIC.

3.2. Measure Phase

The second step of the DMAIC methodology is the measure phase; at this stage, the identification of problem is carried out to fix the problem and find the root cause of the problem. PT. ABC in controlling the production process is guided by customer demand. .

Potential customer demand must be appropriately managed, therefore the PPIC (Production Planning and Inventory Control) department of PT.ABC sets production planning carefully based on customer demand. PT.ABC uses production planning of the rack steering line based on the cycle time with the assumption of high efficiency, low reject, and the most essential thing is minimal line stop. Cycle time in rack steering line is 1.10

minutes and normal capacity of 744 pcs/day. Current production process conditions are described in VSM (Value Stream Mapping). VSM serves as the first step in the waste identification process in the rack steering line.

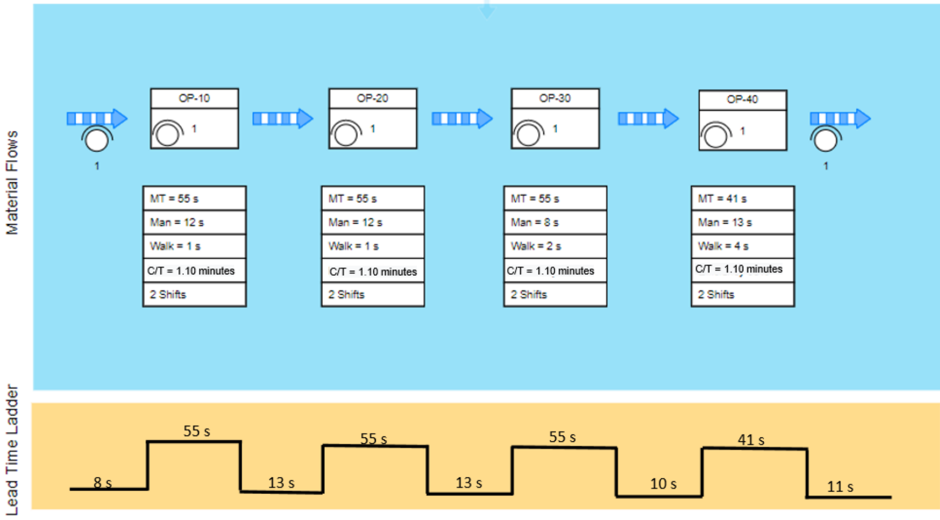

Figure 4. VSM current condition in 1st post

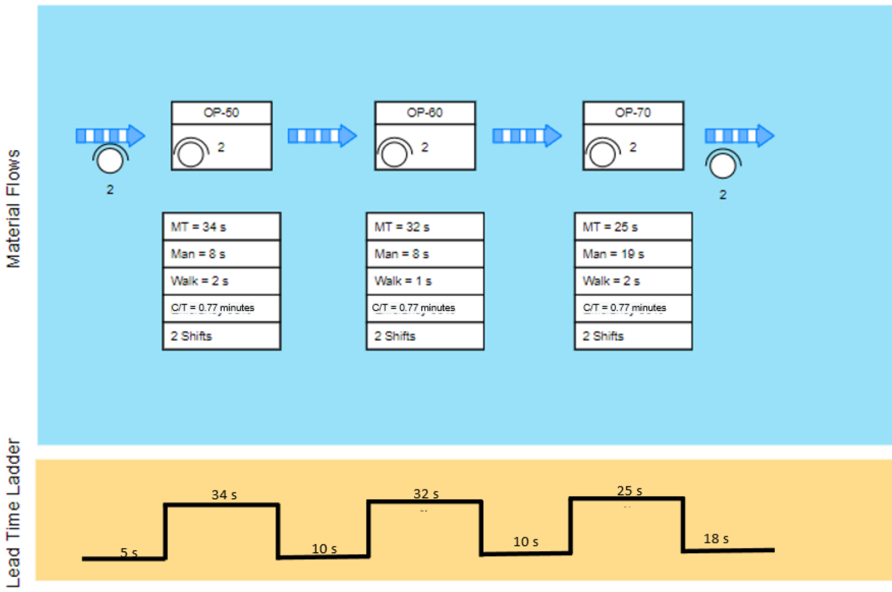

Figure 5. VSM current condition in induction post

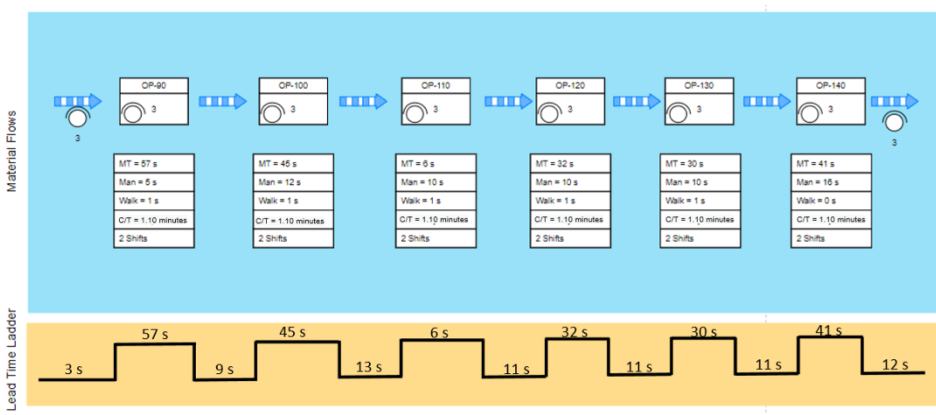

Figure 6. VSM current condition in 2nd post

Based on VSM in Figure 4-6 we can see that in the machining line also rack steering line the dominant time is from machine time if we compare it with other time. Because of that cycle time (C/T) is most influenced by the machine that has the longest time in doing the process. We usually called it the bottleneck in a whole line process. In 1st post has a cycle time of 1.10 minutes with the longest machine time occurring in OP-10, OP-20, and OP-30 of 55 seconds. In induction post has a cycle time of 0.77 minutes with the longest machine time occurring in OP-50 of 34 seconds. The induction post is optimal because the cycle time is lower than the other posts. In 2nd post has a cycle time of 1.10 minutes with the longest machine time occurring in OP-90 of 57 seconds.

3.3. Analyse Phase

The third stage of the DMAIC methodology is analysis. The data obtained in the measure phase is analysed for the root of the problem at this stage.At this stage, process analysis of machine time is carried out. The analysis focuses on the existence of waste, among others:

a. OP-10 (Side Cutting Machine)

The waste of motion is the movement within the process such as the movement of tools in a CNC machine that does not make any value added to the product (Limjeerajarus & et al, 2013). The cutter rotates and the parts go up are tool preparation activities before machining, so that 18 seconds is a potential waste. Free position is the position of moving from cutting to cutter stopped, the tool is in the free position without machining. The cutter rotates and the parts go up and the free position produces a lot of cycle time compared to the machining process, so there is potential for waste.

b. OP-20 and OP-30(Facing, Drill, Tap Machine)

The OP-20 and OP-30 have the same process but with different product sides, so the machine time is the same. The potential waste that occurs in this machine is due to the machine is not suitable enough for the process. OP20 & 30 use an over-spec machine what to empower unused machine. But because of that, the effect is the machine is too big and complex for doing a simple machining process, so the movement takes time, like for door, jig table, tool magazine, etc.Besides that for the machining process center drill, hole chamfer, and tap, some improvement is planned to be done to minimize the processing time.

c. OP-90(*Hizumitori* Finish Machine)

This machine is doing a *hizumitori* process or in English is straightening for the rack that is bending because of the heat treatment process. The *hizumitori* finish process is related to the OP-70 (rough *hizumitori*), the OP-70 process which is not effective enough, resulting in a higher alignment load in the OP-90 (due to repeated processes). So, the potential for waste is caused by the previous process. OP-90 longest time is in the straightening process that needs 6 times to do punch process.

3.4. Improve Phase

The fourth stage of the DMAIC methodology is the improved phase. The root cause of the problem and the solution that has been determined, then corrective action is taken to the problem. Solution testing is carried out to optimize solutions to achieve problem-solving.

Current problems at PT.ABC and the condition of the rack steering line are the basis for attention, especially the machine. Machines that can work optimally by reducing the potential for waste are the goals of the author. The expected target is to reduce the rack steering line cycle time to 1 minute, the following efforts have been made:

a. OP-10 (Side Cutting Machine)

The main process in this machine is cutting, however, several activities do not add value to the product which affects the cycle time. Movement and standby time that is not needed will be optimized. Based on the author's test by re-setting the program, the activities "the cutter rotates and the parts go up" and "free position" can be reduced to 8s and 5s.

b. OP-20 & OP-30 (Facing, Drill, Tap Machine)

OP20 & 30 in the existing condition use Machining centre machine (Enshu JE50S). As we know it is a 5 axis (X.Y, Z, A, and B) horizontal machining centre and has a magazine tool capacity of 24 tools. This type of machine is usually used for machining in a complex work piece.

Our processes that are needed in this OP are not as complex as that, the process is less than 5 and the axis is only two, so it is more suitable for the process to be done using an NC lathe machine. The use of a machining centre in the existing condition is an over-spec condition. The process of the centre drill, hole chamfer, and tap can be accelerated due to the use of new tools with improved materials and coatings. Especially for taps, there are additional improvements in the form of a cooling system through coolant.

c. OP-90 (*Hizumitori* Finish Machine)

OP 90 is the completion of the straightening process, preceded by rough straightening in OP-70 so that the OP-70 and OP-90 have a close relationship and influence one another. If the result in OP-70 quite good the job that should be done in OP90 is more minimal so the amount of punch and rack rotating for measurement can be minimized, from before until 6 times of punch can be minimized to 4 times maximum, with this condition the machine time can be reduced in a big amount.

The position from all of the jig should be modified at the support area so it is possible to do a movement or set the position of the jig. The adjustment is needed so optimization of straightening press could be done, besides that this line also processes rack steering for some cars that have different lengths and diameters, so the optimum position of jig and punch is also different.

3.5. Control

The last step of the DMAIC method is the control phase, the control phase is used to maintain the improvements that have been made in the improve phase. Several things that need to be controlled are cycle time and normal capacity.

IV. RESULTS &DISCUSSION

Machine improvement is carried out on OP-10 machines by reducing non-value activities, OP-20 and OP-30 tool changes are carried out to avoid over-spec, and adjusting the OP-70 jig which has an impact on the OP-90. So that the changes in machine time are as follows:

Table 1. Comparison of machine time

Machine	Original Machine time (s)	Est. Machine time (s)	Change (s)
OP-10	55	42	13
OP-20	55	49	6
OP-30	55	49	6
OP-90	57	51	6

Changes in machine time affect the determination of a new cycle time by the posts that make improvements. OP-10, OP-20, and OP-30 are part of the 1st post, so the cycle time changes from 1.10 minutes to 1.00 minute. Induction post doesn't change cycle time because there is no change in machine time in this post. OP-90 is part of the 2nd post, the cycle time changes from 1.10 minutes to 1.0 minutes.Based on the reduction in cycle time at each post, the determination of a new cycle time in the rack steering line, from 1.10 minutes to 1.00 minutes and normal capacity is increased to 818pcs/day.

V. CONCLUSION

In this research, Lean Six Sigma principles can be used to optimize production lines by analyzing existing waste. Machine time was found to be a bottleneck in the process, so it was increased and cycle time decreased. By the principles of Lean Six Sigma using the DMAIC method, the cycle time decreased in the rack steering line from 1.1 minutes to 1.0 minutes. The decrease in cycle time has an impact on the increase in normal capacity from 744pcs / day to 818 pcs / day, so that overtimecost can be minimized. The company can meet customer demand by minimizing overtimecost.

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**Corresponding Author: FarhanHarastaFadruzil*
[1](School of Business and Management, InstitutTeknologi Bandung, Bandung)