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| RESEARCH ARTICLE

Implementation of a Lean Production System using Materials and Information Flow Chart in Electroplating Services Company

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| ABSTRACT
With the transformation of the electroplating service industry as a second-tier supplier in the automotive industry, significant changes have occurred in production processes, management, and technology to answer global market challenges. The main focus is reducing costs and increasing profitability through improving quality and productivity. In order to achieve this goal, the Lean Production System or Toyota Production System is used to analyze and reduce waste in the production process. Process flow modelling with a Material and Information Flow Chart (MIFC) helps to visualize all activities that give an additional value or not to the product. The research method involves using 7 quality management tools and Failure Modes and Effect Analysis (FMEA) to evaluate and improve areas that affect quality and productivity. This approach aims to deliver quality products to customers at low cost through systematic changes and process improvements.

| KEYWORDS

Lean Production System, Toyota Production System, MIFC, VSM.

| ARTICLE INFORMATION

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1. Introduction

The industry is an economic activity where raw materials are processed and manufactured in factories. Industry has an important role in the growth and development of a region. According to Indonesia's Ministry of Industry (2021), the automotive manufacturing industry is a mainstay sector because it has made a large contribution to the national economy. Currently, there are 22 automotive manufacturers in Indonesia, including Honda, Daihatsu, Toyota, Suzuki, and others.

In the automotive industry, automotive manufacturers need to collaborate with component manufacturers or service manufacturers to obtain prime quality at low costs. Component manufacturers can supply almost 70% - 100% of the components in a vehicle (Sambharya and Banerji, 2006). Manufacturing Electroplating services is a second-tier supplier for automotive manufacturers. Electroplating is commonly known as gilding; electroplating can be interpreted as a metal coating process, using the help of an electric current and certain chemical compounds to transfer metal particles that act as a coating to the Material to be coated to add visual value, durability, and hardness (Triyano et al., 2019).

The electroplating services manufacturing industry has significantly changed production processes, management approaches, and process technology. In addition, there is an increasing customer demand for their services (Sharma and Modgil, 2016). Therefore, the electroplating services industry is challenged to improve its performance and follow the changes occurring in the global market quickly and precisely. Apart from that, manufacturers also want to increase their profitability to survive amidst the current economic fluctuations (Kumar et al., 2020). However, an obstacle is often found: products (services) are unable to compete with their competitors due to the high selling prices and high production costs due to ineffective and inefficient production processes. **Figure**

1. is a comparison graph between incoming and delivery for every month at the beginning of the 2023 semester and compared with installed capacity data.

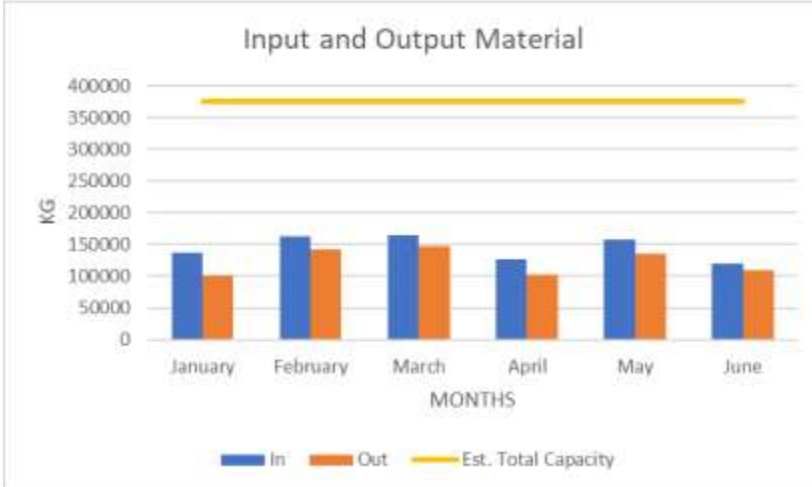


Figure 1. Incoming and Delivery of Monthly Data in Electroplating Company (The place where the researcher doing research)

According to Kumar et al. (2020), Manufacturing needs to improve quality and productivity by reducing production time, additional work time, labor, and production costs and by organizing existing processes into processes that lead to increased production using the Toyota production system that eliminates waste (Muda). The Toyota production system (TPS) (in the US, more commonly called "lean manufacturing") has been widely studied starting in the 1970s (Marksberry et al., 2010). TPS is a business model that focuses on systematic identification to eliminate useless things from a process that involves changing and improving processes.

Implementing Lean-TPS is not easy; companies can face many difficulties and obstacles along the way. In their research, Chiarini et al. (2018) studied how to handle a failure during the implementation of Lean-TPS. TPS offers many tools such as 5S (seiri, seiton, seiso, seiketsu, and shitsuke), Kanban, Value Stream Mapping (VSM), and more complex techniques such as single-minute-exchange-of-die (SMED) and total productivity maintenance (TPM) (Monden, 2011). VSM, one of those tool, is used to understand the entire flow of materials, starting from procurement of raw materials, transformation of these materials into required products known as finished products, and delivery of finished products to customers (Aadithya et al., 2022). VSM is an adaptation of an original technique from Toyota called the "Materials and Information Flow Chart (MIFC)," which is used to represent and analyze all processes and activities (both "added" and "non-added" value) allowing for the quantification of production time and identify opportunities for improvement (Gurumurthy and Kodali, 2010). An important characteristic of MIFC is its visual nature, which allows a quick assessment of the state of the production process (Carvalho et al., 2018).

On the implementation, most of the activities that were as optimal as Toyota failed because the techniques were used slowly and with little understanding. If Lean or TPS is a method that develops continuously, the company needs constant and consistent participation management. One of the activities or approach methods from TPS that is interesting as a focus and can also create a clear picture of Lean manufacturing is Jishuken. It has two main objectives: to solve workplace problems that require management attention and to correct, enrich, and deepen the understanding of TPS by management by directly applying problem-solving principles using hands-on activities (Marksberry et al., 2010).

This research aims to implement a Lean production system using a Material and Information Flow Chart for continuous improvement to reduce unnecessary additional processing time in the electroplating services industry.

2. Literature Review

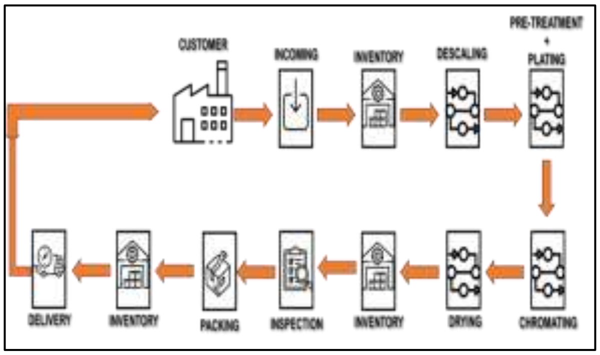
Previous research has shown TPS or lean manufacturing has been widely applied; one of the research from Costa and Godinho Filho (2016) explains the implementation of Lean has been extended from Lean production to Lean health services, Lean in government (Suarez Barraza et al., 2009), Lean in fabrication industry (Aadithya et al., 2022) and Lean have even become environmentally friendly and are used to improve environmental performance (Garza-Reyes, 2015). Vanichchinchai (2022) applies Lean to the world of healthcare to examine the relationship between leadership and culture, human resources, and process improvement using a socio-technical perspective. Lean manufacturing in India's small and medium enterprises (SMEs) is also explained (Ramadas & Satish, 2021).

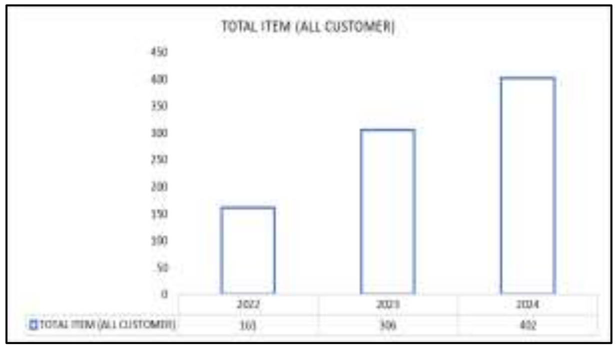
In their research, Soltani et al. (2022) developed an integrated Fuzzy MCDM model to improve the implementation of the conventional Lean Manufacturing (LM) approach. The results confirm its effectiveness and show that using the MCDM approach in the LM implementation process provides positive and flexible results. Ramani and Lingan (2019) developed Lean in construction management, where a case study was carried out for the Lean concept applied using the Value Stream Mapping tool to reduce the cost of the gas-insulated switchgear foundation design process by increasing process productivity.

Overall, this research aims to implement a Lean production system using Value Stream Mapping as a method and a basis for continuous improvement to reduce unnecessary additional processing time in the electroplating services industry.

3. Methodology

Figure 2a. Overview of the Process, **2b.** Material Growth in research place's company





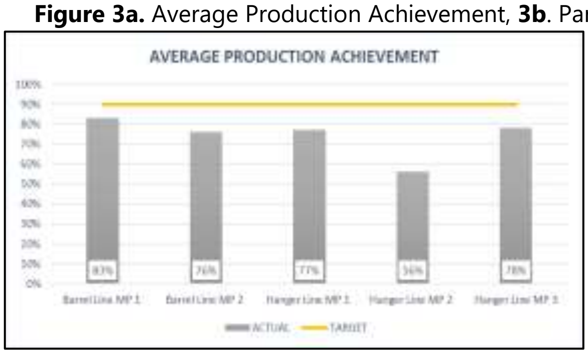
Material is taken from the customers (pipe, clamps, wire, bolts, etc.), and the next receiving process is carried out, where quality and quantity are checked. The production process is carried out and ends with delivery back to the customer based on Figure 2a. The total types of customer's parts processed at the electroplating company where the research was conducted for the entire line is 306 part items; 101 part items are in the MP2 Hanger Line, and 28 types are global parts that are sent to another country, such as Brazil, Japan, Malaysia, and Vietnam. The large number of customers who entrust their products to be processed by plating (metal coating) first before becoming a finished product has led to the growth of one of the electroplating companies where this research is carried out, shown in Figure 2b.

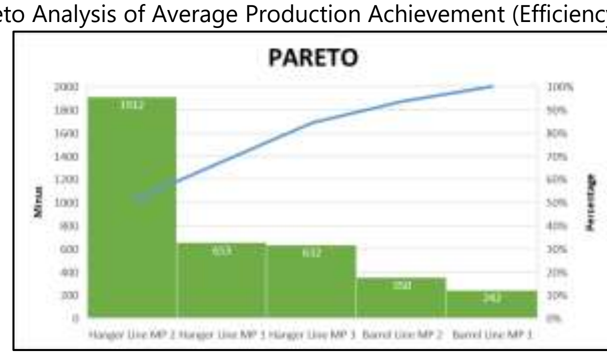
It is necessary to monitor the achievement results, especially in the Pre-Treatment - Plating - Chromating process line, which is the core process shown in Figure 3a. After collecting data and analyzing each production line in the Pre-Treatment-Plating-Chromating process, then making an analysis using the "PARETO diagram," we will get the correct data analysis, as we will see in Table 1 and Figure 3b.

Table 1 Data Average Production Achievement Pareto Analysis

Line Name	Unit	Target	Actual	Status	Minus	%Not Achieve	%Achieve	Priority
Barrel Line MP 1	Barrel	1430	1188	X	242	17%	83%	5
Barrel Line MP 2	Barrel	1430	1080	X	350	24%	76%	2
Hanger Line MP 1	Hanger	2808	2155	X	653	23%	77%	3
Hanger Line MP 2	Hanger	4368	2456	X	1912	44%	56%	1
Hanger Line MP 3	Hanger	2912	2280	X	632	22%	78%	4

Figure 3a. Average Production Achievement, **3b**. Pareto Analysis of Average Production Achievement (Efficiency) Data





The series of production processes can explain the areas that are responsible for the work process, especially on the MP2 hanger line production machine, which includes Descaling, Pre-Treatment – Plating – Chromating, Drying, Inspection, and there are "waste" processes. So, the process at the workstation can be divided into two, Value Added (VA) & Non Value Added (NVA), so planning improvement can be carried out in areas that have a fairly high %(NVA). The VA & NVA data can be viewed in Table 2.

Table 2 VA & NVA data based on flow for Material Processed on Hanger Line MP 2

No	Flow Proses	Total Production Time (H)	Total Change Overtime/ Day (H)	Loading Total Time (H)	Hours		%	
					VA	NON VA	VA	NON VA
1	Incoming	16,67	0,83	17,50	16,7	0,8	95%	5%
2	Descaling	17,50	0,68	18,18	17,5	0,7	96%	4%
3	Pre-Treatment + Plating + Chromating. (Hanger Line MP2)	17,50	3,38	20,88	17,5	3,4	84%	19%
4	Drying	18,67	0,70	19,37	18,7	0,7	96%	4%
5	Inspection	20,00	1,00	21,00	20,0	1,0	95%	5%
6	Packing	16,67	0,63	17,29	16,7	0,6	96%	4%

From the results of the analysis on the graph in Figure 3a and data in Table 1 and Table 2 in this research, it can be determined which problem work areas should be used as the main project, in this case, the Pre-Treatment-Plating-Chromating Line for the subline "MP 2 Hanger Line". Then, create a material and information flow chart with 3 simulations: the current condition, which will be called the material and information flow chart (MIFC) current; the ideal condition (MIFC ideal); and the last one is a target condition (MIFC target) that will be achieved after making improvements.

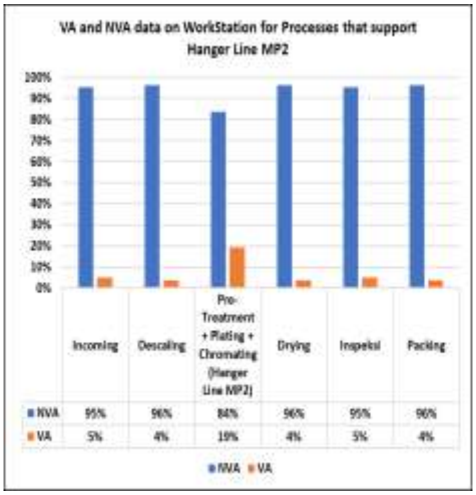
4. Result and Discussion

4.1. Production Process Efficiency Analysis

Based on the data analysis in Table 1, Hanger Line MP2 has the most considerable non-efficient process value, with a percentage of 44%. Then, from Figure 3b, Pareto analysis was carried out, and it was found that Hanger Line MP 2 had a minus distribution of around >90% of the total minus production achievements on the Pre-Treatment – Plating – Chromating line. Therefore, we can say that the MP2 Hanger Line area is a suspect that will require repairs.

4.2. Comparative Analysis of Value Added and Non-Value Added in Process Areas

From the efficiency data for each pre-treatment - plating - chromating line contained in Table 1, it can be seen that Hanger Line MP2 is a priority line that requires improvement due to the low performance of this line. A continuous analysis was carried out for all workstations in the electroplating production process supporting the MP2 Hanger Line process. Then, data was obtained as VA & NVA data poured into the graph in Figure 4a. It can be seen that the PreTreatment - Plating - Chromating process has a process value that has the highest NVA; therefore, the PreTreatment - Plating - Chromating workstation process will be the main focus because the high percentage of NVA is the process with the highest waste, which can affect production costs, achievement of production (output), from the company.



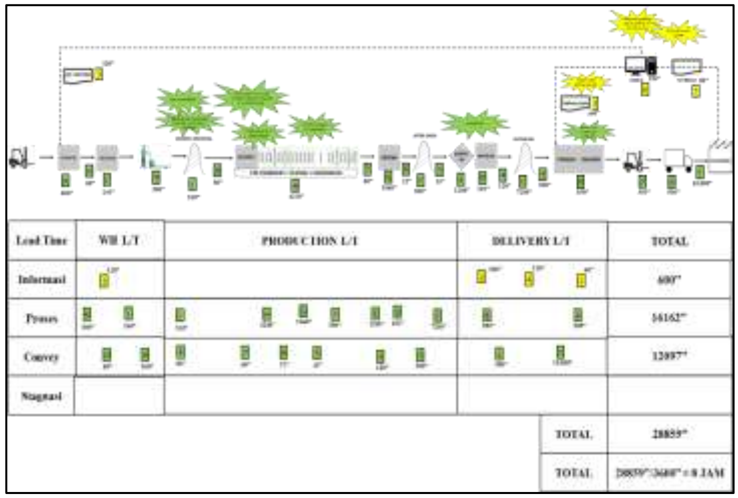


Figure 4a. VA and NVA in every workstation, **4b**. Material and Information Flow Chart Current

4.3. Material and Information Flow Chart Current Condition

The flow of information and materials is depicted from right to left. This is to reflect the concept of reversal orientation used in some Lean diagrams to highlight a shift in perspective from a customer or market point of view towards an organization's internal processes. From Figure 4b, which is a picture of the Material and Information Flow Chart's actual state before improvements are made, you can see the results obtained for processing lead time values , which are divided into three types of process forms, namely Delivery Lead Time, Production Lead Time, Ware House Lead Time. The total lead time value obtained is 28,859 seconds, or the same as 8 hours.

4.4. Material and Information Flow Chart (MIFC) Ideal

Ideal MIFC is a visual representation of the placement and movement of materials and information in a business process that is considered optimal or ideal value. Figure 5 shows that the lead time obtained is shorter, and the process flow is also more concise compared to the current situation. In the ideal MIFC, the total lead time equals 4.9 hours, which is 61% of the current lead time, with the total lead time dropping to 4.9 hours from the actual 8-hour total lead time.

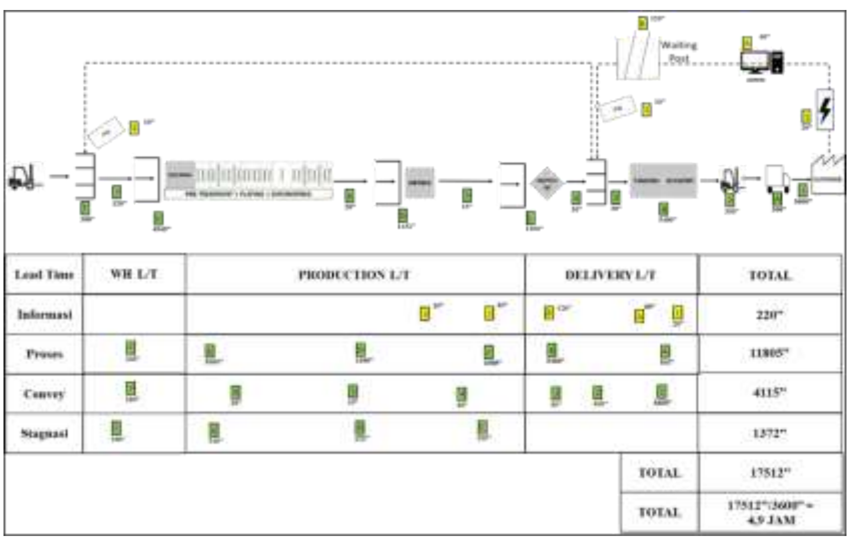


Figure 5. Material and Information Flow Chart Ideal

4.5. Analysis of Existing Conditions

One way is to analyze existing conditions by using the philosophy of the Toyota way, namely GENBA (Real Place), GENBUTSU (Real Thing) & GENJITSU (Real Fact), after which we can use several tools such as fish bones.) and FMEA (Failure Mode Effect Analysis).

4.5.1. Fishbone Diagram Analysis (Fishbone)

Analysis was carried out using the fishbone diagram method, which is a cause-and-effect diagram. In this research, analysis was used using 4M + 1E categories, or more specifically, man, method, machine material, and finally, the manufacturing environment. The fishbone diagram for research is in Figure 6 and expanded to Table 3.

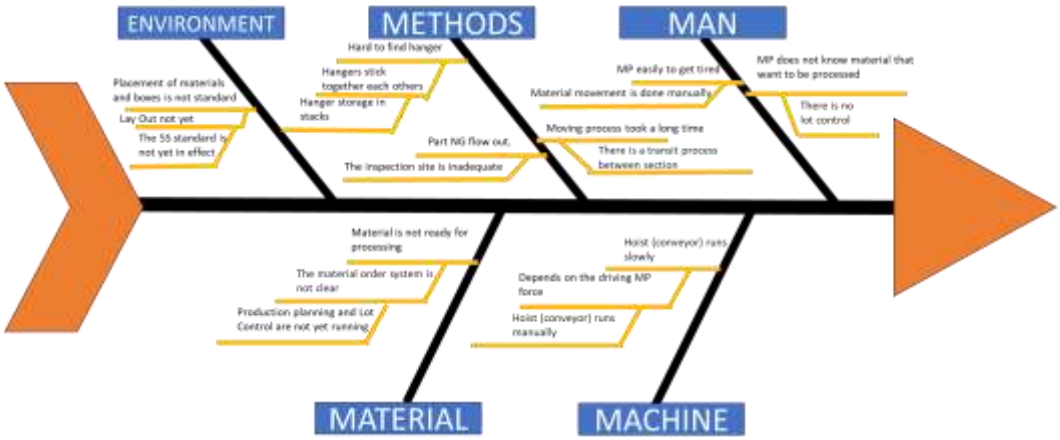


Figure 6. Fish Bone Diagram

Table 3. Problem Cause Analysis Data

Category	Problem Classification	Cause of Problem	Effect
Man	Design Process	Part movement is done manually	MP easily gets tired
	Planning	No lot control (Production Card)	MP does not know the material that wants to be processed
Material	Planning	Production planning and Lot control are not yet running	Material is not ready for processing
Machine	Design Process	Hoist (conveyor) manual	Hoist runs slowly
Method	Design Process	Hanger storage in stacks	Hard to find hanger
	Design Process	There is a transit process in each section	Moving process took a long time
	Design Process	The inspection site is inadequate	Part NG flow out.
Environment	Planning	The 5S standard is not yet in effect	The placement of materials and boxes is not standard

4.5.2. FMEA (Failure Mode Effect Analysis)

Analysis was carried out using the Failure Mode Effect Analysis method, where the analysis is carried out based on the effects of failure. Levin et al. (2019) explained that FMEA is the most powerful tool that can be easily applied without using expensive tools. In determining the FMEA to be able to determine the priority of improvements to be carried out, the RPN (Risk Priority Number) value is needed so that there is a scale for each problem. In determining the risk priority number, it is necessary to determine a level or scale for other parameters, namely Severity (S), Occurrence (O), and Detection (D).

Table 4. Data Risk Priority Number (RPN)

Cause of Problem	Scale			RPN	Rank	Activity Improvement
	S	O	D			
Part movement is done manually	3	4	1	12	5	Hoist repair (automatization)
No lot control (Production Card)	2	3	2	12	7	An order by kanban system is implemented. Items without Lot control or process cards cannot be pulled into the process.
Production planning and Lot control are not yet running	2	3	2	12	8	An order by kanban system is implemented. Items without Lot control or process card cannot be pulled into process.
Hoist (conveyor) manual	4	4	1	16	4	Hoist repair (automatization)
Hanger storage in stacks	3	2	3	18	3	Storage Hanger Repair
The inspection site is inadequate	3	3	2	18	2	Re-Design the sorting table by following customer standards
Transit process in each section	3	3	3	27	1	Elimination of the transit system
The 5S standard is not yet in effect	4	3	1	12	6	Carrying out Genba 5S at the start of the shift and conducting briefings at each shift

4.6. Implementasi Material and Information Flow Chart Target

The material and information flow chart (MIFC) target condition diagram is a description that refers to the desired state or target before reaching ideal conditions. After carrying out the analysis using fish bone and then FMEA, priority improvements (kaizen) were obtained, where the data can be seen in Table 4. Furthermore, continuous monitoring and evaluation are carried out on the improvements made in each area through the Jishuken program with continuous frequency. The observations are made by paying attention to the process's lead time, which is also part of the current MIFC and ideal MIFC. The data can be seen in Table 5. Next, formulation or description is carried out as a Material and Information Flow Chart Target, as seen in Figure 7.

Table 4. Data Risk Priority Number (RPN)

No	MIFC	Ware House L/T (S)	Production L/T (S)	Delivery L/T (S)	Total L/T (S)
1	Current Condition	1.320	15.059	12.480	28.859
2	Target Condition (After Jishuken)	980	12.012	12.020	25.012
3	Ideal	420	7.262	9.830	17.512

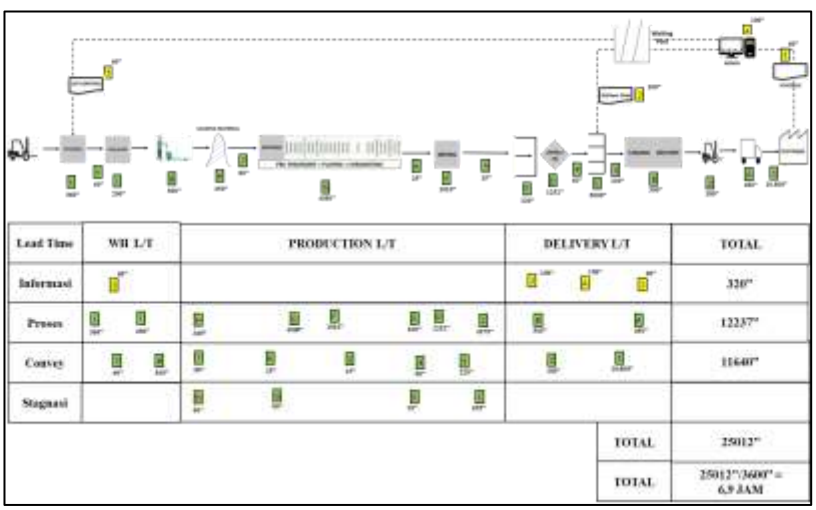


Figure 7. Material and Information Flow Chart Target

5. Conclusion

Data collection and data processing have been carried out, and then stages are carried out in designing the production process by referring to Lean-TPS in outline, which consists of material and information flow charts of current conditions before improvements are made. Next, describe the optimum ideal conditions, analyze the existing data, and continue by determining the repair process and implementing target conditions (MIFC target). Improvements made to the flow process in service manufacturing companies in this research were carried out using the Material and Information Flow Chart (MIFC) method, which was carried out internally at the company. The research focused on the "MP2 Hanger Line Area" in the PreTreatment-Plating-Chromating production process, which has the highest %NVA of 19% and the lowest production achieved at 56%. From the MIFC current conditions that have been formulated, improvement actions are then carried out so that better results are obtained, which are WareHouse Lead time in the situation after the upgrade decreased by 340 Seconds, or equivalent to 25.7% of the total initial Lead time (MIFC current), Production Lead time in the situation after the upgrade was carried out decreased by 3047 Seconds, or equivalent to 20.2% of the total initial Lead time (MIFC current), Delivery Lead time in the situation after the upgrade was carried out decreased by 460 Seconds, or the equivalent of 3.7% of the total initial Lead time (MIFC current). So, because the lead time is reduced, it also simulant to the cost of production and lost unnecessary additional processing.

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