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Implementation of Value Stream Mapping for Waste Reduction in Crude Palm Oil Production Process

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Abstract *— PT. Perkebunan Nusantara I Cot Girek is one of the palm oil mills owned by PT. Perkebunan Nusantara I which is engaged in processing palm oil into Crude Palm Oil and Palm Kernel Oil. The problem faced by PTPN I Cot Girek Unit is that there are several wasteful activities that cause the company to experience time losses, production does not reach targets and quality damage to Fresh Fruit Bunch (FFB) and Coconut Palm Oil (CPO). The problem solving method used are Value Stream Mapping to identify wasteful activities, the 5W1H method to identify the causes of waste and the Weighted Product Method to determine the order of priority for improvement. Based on the results of the study, there are 4 activities that can be taken corrective action. After being analyzed using VSM, it was found that the Manufacturing Lead Time decreased from 1185.70 minutes to 1069.73 minutes and the Process Cycle Efficiency value increased from 67% to 74%.*

Keywords *— CPO, Value Stream Mapping, Waste, 5W+1H*

I. INTRODUCTION

Industrial companies are currently experiencing very rapid development so that every company must continue to improve its competitiveness. Superior competition is shown in the ability of a company to produce products on time, with the right quality, in the right quantity and at competitive prices. One of the keys to a company's competitive ability lies in the quality of the entire production process. Good quality will only be obtained if the entire production process runs optimally as planned. To achieve the optimal production process, the company is required to have a strategy, one of which is to reduce or eliminate waste along the flow of the production process. Waste can be defined as all non-value added activities in the process of transforming inputs into outputs in the production flow. To conduct a more in-depth study to reduce waste, one way that can be applied is the Lean Manufacturing method. Mekong Capital (2004) stated, lean manufacturing is also known as lean production, which is a tool and methodology aimed at the continuous elimination of all waste in the production process. The main benefits of this concept are lower production costs, increased output and shortened production lead times. According to Heizer and Render (2009), waste that often occurs in the business processes of a factory / industry is the presence of defective products, excess inventory, wasted time and so on.

The lean manufacturing tools used in this study to minimize waste is Value Stream Mapping. According to Sandroto (2007), Value Stream Mapping is a visual method to map the production line of a product which includes materials and information from each work station. The reason for using the VSM method is because this method presents all value-added and non-value-added activities from raw materials to finished products. VSM also can be used as a starting point for company to identify waste and its causes.

Furthermore, an analysis of the causes of waste is carried out using the 5W+1H method. 5W+1H method is an action plan, whether it is to improve a process or identify a problem that occurs (Gasperz, 2011).

PT. Perkebunan Nusantara I Cot Girek Unit is one of the palm oil mills owned by PT. Perkebunan Nusantara I which is engaged in processing palm oil fresh fruit bunches (FFB) into Crude Palm Oil and Palm Kernel Oil. The problem that has occurred so far in the production process of Crude Palm Oil (CPO) in this company is that there is still a lot of waste in terms of production time due to inefficient production activities in its production activities. According to the Factory Manager as the party responsible for all production activities, there are only four activities that allow improvements to be made with a total waste of 241.93 minutes. The impact caused by these wasteful activities are: the company suffers time losses, production does not reach the target and quality

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damage to FFB and CPO. Based on these conditions, a research was conducted to solve the waste problem using the Value Stream Mapping method and the Weighted Product Method.

II. METHOD

The stages carried out in this research, starting from identifying the waste that occurs in the production process. Next, conduct a preliminary study to determine the problem-solving method. Data collection is used as input in the study. Data processing use Lean Manufacturing approach with the Value Stream Mapping method to identify activities that are classified as waste and 5W + 1H analysis to determine the root of the problem.

Data collection techniques in this study were carried out by:

1) Direct observation and direct measurement.
   In this case, direct observations were made at the production department to measure the time of the production processes, assess the rating factor, determine the allowance, and determine the causes of waste.
2) Interview.
   In this study, interviews were conducted through discussions with operators and factory managers to obtain the required data.

III. RESULT AND DISCUSSION

A. Rating Factor Assessment

Rating factor is a factor obtained by comparing the work speed of an operator with the normal work speed according to the researcher / observer (Wignjosoebroto, 2006). Rating factor assessment is carried out using the Westinghouse method to measure the level of fairness of an operator's work. In this study, the calculation of the rating factor value considers 4 factors, namely skill, effort, condition and consistency. The results of the westinghouse factor on the operator can be seen in table 1.

Table 1
Recapitulation of Rating Factor

Operator	Westinghouse Factor	Rating Factor
Weighting	0,07	1,07
Loading Ramp	0,05	1,05
Sterilization	0,08	1,08
Thresher	0,03	1,03
Digester	0,01	1,01
Press	0,11	1,11
Vibrating Screen	0,04	1,04
Continuous Storage Tank	0,05	1,05
Vacuum Dryer	0,11	1,11
Storage & Despatch	0,05	1,05

Then, the allowance determination for each operator is carried out. The recapitulation of allowance for each operator can be seen in Table 2.

Table 2
Allowance Determination

Operator	Total Allowance (%)
Weighting	5
Loading Ramp	13
Sterilization	34
Thresher	40,5
Digester	47
Press	54
Vibrating Screen	48
Continuous Storage Tank	53
Vacuum Dryer	30
Storage & Despatch	7,25

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B. Standard Time Calculation

Standard time is a calculation of the time required by an operator to complete his unit of work with the addition of an allowance factor in normal time. Examples of calculating normal time and standard time for the first process are as follows:

Rating factor = 1,07
Allowance = 5%
Cycle time = 4,18
Normal time = Cycle time x Rating factor
= 4,18 x 1,07 = 4,47

$$\text{Standard time} = \text{Normal time} \times \frac{100\%}{100\%-\text{Allowance}}$$

$$= 4{,}47 \times \frac{100\%}{100\%-5\%} = 4{,}71$$

The recapitulation of the calculation results of normal time and standard time for each process can be seen in Table 3.

Table 3
Recapitulation of Standard Time

Work Processes		Cycle Time	Rating Factor	Normal Time	Allowance (%)	Standard Time
1	Fresh Fruit Bunch (FFB) weighing	4,18	1,07	4,47	5	4,71
2	FFB is brought to the Loading Ramp station	3,14	1,05	3,30	13	3,79
3	FFB unloaded from truck	16,84	1,05	17,68	13	20,32
4	FFB sorting	4,33	1,05	4,55	13	5,23
5	FFB temporarily stacked while waiting for empty lorry from Threshing station	51,65	1,00	51,65	0	51,65
6	TBS inserted into the Loading Ramp	17,85	1,08	19,28	34	29,21
7	Loading FFB into the lorry	3,45	1,08	3,72	34	5,64
8	Lorry taken to Sterilizer Station	1,06	1,00	1,06	0	1,06
9	The lorry is put into the Sterilizer machine for the FFB boiling process	120	1,08	129,60	34	196,36
10	The lorry is pulled out from the boiler	1,14	1,08	1,24	34	1,87
11	The lorry waiting to be lifted using Hoisting Crane	6,50	1,00	6,50	0	2,50
12	Boiled fruit from the lorry is poured into the Thresher machine	39,03	1,03	40,20	40,5	67,57
13	The loose fruit is crushed in the Digester machine	11,51	1,01	11,62	47	21,93
14	The loose fruit is pressed in the presser machine to produce dirty CPO	13,91	1,11	15,44	54	33,58
15	Dirty CPO is brought to the Clarification Station for purification	2,35	1,11	2,61	54	5,68
16	Dirty CPO deposited in Sand Trap	33,78	1,00	33,78	0	33,78
17	Dirty CPO is filtered using Vibrating Screen	18,78	1,04	19,54	48	37,57
18	Dirty CPO is temporarily stored in Crude Oil Tank	15,51	1,00	15,51	0	15,51
19	Dirty CPO is taken to Continuous Storage Tank to separate oil, water and sludge	180	1,05	189,00	53	402,13
20	The separated oil is deposited in the Pure Oil Tank	35,86	1,00	35,86	0	35,86
21	The oil is put into the Vacuum Dryer	15,12	1,11	16,78	30	23,98

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	machine to reduce the water content so that pure CPO is produced					
22	Pure CPO flows into the Storage Tank	6,35	1,00	6,35	0	6,35
23	Pure CPO waiting to be loaded into delivery trucks	150	1,00	150	0	150
24	Filling CPO into delivery trucks	26,90	1,05	28,24	7,25	30,45

C. Manufacturing Lead Time and Process Cycle Efficiency Calculation

Manufacturing Lead Time is the time required to carry out the production process from start to finish based on standard time. Manufacturing Lead Time calculation is done by adding up the entire work process time which consists of 24 work processes. Manufacturing Lead Time calculation results can be seen in Table 4.

Table 4
Manufacturing Lead Time Calculation

Work Processes		Standard Time
1	Fresh Fruit Bunch (FFB) weighing	4,71
2	FFB is brought to the Loading Ramp station	3,79
3	FFB unloaded from truck	20,32
4	FFB sorting	5,23
5	FFB temporarily stacked while waiting for empty lorry from Threshing station	51,65
6	TBS inserted into the Loading Ramp	29,21
7	Loading FFB into the lorry	5,64
8	Lorry taken to Sterilizer Station	1,06
9	The lorry is put into the Sterilizer machine for the FFB boiling process	196,36
10	The lorry is pulled out from the boiler	1,87
11	The lorry waiting to be lifted using Hoisting Crane	2,50
12	Boiled fruit from the lorry is poured into the Thresher machine	67,57
13	The loose fruit is crushed in the Digester machine	21,93
14	The loose fruit is pressed in the presser machine to produce dirty CPO	33,58
15	Dirty CPO is brought to the Clarification Station for purification	5,68
16	Dirty CPO deposited in Sand Trap	33,78
17	Dirty CPO is filtered using Vibrating Screen	37,57
18	Dirty CPO is temporarily stored in Crude Oil Tank	15,51
19	Dirty CPO is taken to Continuous Storage Tank to separate oil, water and sludge	402,13
20	The separated oil is deposited in the Pure Oil Tank	35,86
21	The oil is put into the Vacuum Dryer machine to reduce the water content so that pure CPO is produced	23,98
22	Pure CPO flows into the Storage Tank	6,35
23	Pure CPO waiting to be loaded into delivery trucks	150
24	Filling CPO into delivery trucks	30,45
	Total Manufacturing Lead Time	**1186,70**

Next is the calculation of Process Cycle Efficiency, which is a measure that identifies a number of processes that provide added value. In calculating the value of the Process Cycle Efficiency, the first thing that must be done is to classify the value-added activities with the non-value-added activities. The recap of value added time and non-value added time can be seen in Table 5.

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Table 5
Value Added Time and Non-Value Added Time

	Work Processes	Value Added Time (minutes)	Non Value Added Time (minutes)
1	Fresh Fruit Bunch (FFB) weighing	4,71	
2	FFB is brought to the Loading Ramp station		3,79
3	FFB unloaded from truck		20,32
4	FFB sorting	5,23	
5	FFB temporarily stacked while waiting for empty lorry from Threshing station		51,65
6	TBS inserted into the Loading Ramp		29,21
7	Loading FFB into the lorry		5,64
8	Lorry taken to Sterilizer Station		1,06
9	The lorry is put into the Sterilizer machine for the FFB boiling process	196,36	
10	The lorry is pulled out from the boiler		1,87
11	The lorry waiting to be lifted using Hoisting Crane		2,50
12	Boiled fruit from the lorry is poured into the Thresher machine	67,57	
13	The loose fruit is crushed in the Digester machine	21,93	
14	The loose fruit is pressed in the presser machine to produce dirty CPO	33,58	
15	Dirty CPO is brought to the Clarification Station for purification		5,68
16	Dirty CPO deposited in Sand Trap		33,78
17	Dirty CPO is filtered using Vibrating Screen	37,57	
18	Dirty CPO is temporarily stored in Crude Oil Tank		15,51
19	Dirty CPO is taken to Continuous Storage Tank to separate oil, water and sludge	402,13	
20	The separated oil is deposited in the Pure Oil Tank		35,86
21	The oil is put into the Vacuum Dryer machine to reduce the water content so that pure CPO is produced	23,98	
22	Pure CPO flows into the Storage Tank		6,35
23	Pure CPO waiting to be loaded into delivery trucks		150
24	Filling CPO into delivery trucks		30,45
	Total	**793,04**	**393,66**

$$\textit{Process Cycle Efficiency} = \frac{\textit{Value Added Time}}{\textit{Manufacturing Lead Time}} = \frac{793{,}04}{1186{,}70} = 67\%$$

D. Current Value Stream Mapping Establishment

According to Rother, M., and Shook, J (2009), value stream is described as all activities and information that add value and do not add value to the product for all business processes. The purposes of this mapping are to identify all types of waste that occur throughout the production process and to take corrective steps in an effort to eliminate waste. The Current Value Stream Map (CVSM) of the Crude Palm Oil (CPO) production process can be seen in Figure 1.

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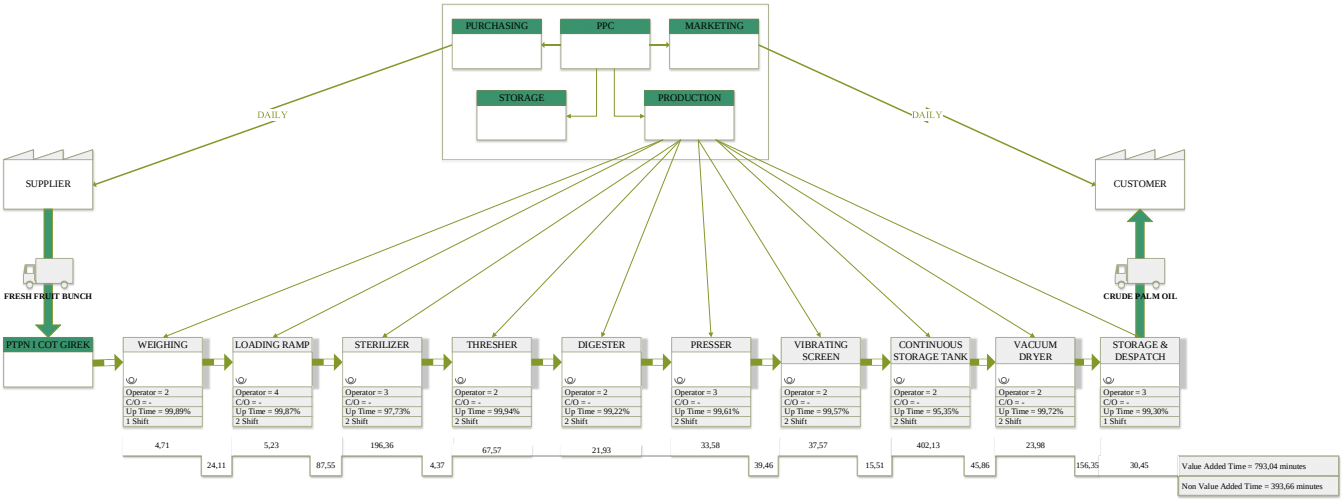

Fig 1: Current Value Stream Mapping

E. Waste Identification

Based on the results of the Current Value Stream Mapping (CVSM) design, the waste activities that allows for improvement are:

Table 6
The Selected Waste Activities

No	Waste Activities	Minutes
1	FFB temporarily stacked while waiting for empty lorry from Threshing station	51,65
2	The lorry waiting to be lifted using Hoisting Crane	2,50
3	Dirty CPO deposited in Sand Trap	33,78
4	Pure CPO waiting to be loaded into delivery trucks	150

Furthermore, the causes of the waste activities were analyzed using the 5W+1H method so as to reduce production time and increase efficiency. 5W + 1H method is a technique that allows to understand the situation and see the problem by analyzing all aspects (Daman, 2020). Analysis of waste activities using the 5W+1H method can be seen in Table 7.

Table 7
5W+1H Analysis

Activities	Analysis	Explanation
FFB temporarily stacked while waiting for empty lorry from Threshing station	What	There is wastage in waiting time and damage to the quality of FFB.
	Who	Loading Ramp Operator
	Where	Loading Ramp Station
	When	After FFB is sorted and before FFB is added to the loading ramp
	Why	Limited available lorries
	How	Waiting activities can be minimized by implementing the First in First Out (FIFO) system, lorries must be fully filled according to their capacity (±2.5 tons), minimizing fruit that is susceptible, and adding more lorries.
The lorry waiting to be lifted using Hoisting Crane	What	There is wastage in waiting time
	Who	Thresher Operator
	Where	Thresher Station

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	When	After the boiling process and before the threshing process
	Why	There are only 2 hoisting crane operators, while the boiled lorry that will be lifted to the threshing station is 4.
	How	Waiting activities can be minimized by applying the First in First Out (FIFO) system, the slings must be adjusted correctly, and the operator must be agile
Dirty CPO deposited in Sand Trap	What	There is an iterative process because the NOS (Non Oil Solid) that comes out is still very thick.
	Who	Clarification Operator
	Where	Sand Trap Station
	When	During the refining process
	Why	Temperatures did not reach the standard
	How	The temperature must be set according to the standard (95^oC-115^oC) for effective purification, regular sand removal every 4 hours, and the Sand Trap should be equipped with a diluent tank to extract the oil contained in the sludge.
Pure CPO waiting to be loaded into delivery trucks	What	There is wastage in waiting time and damage to the quality of FFB.
	Who	Delivery department
	Where	Storage & Despatch Station
	When	Before CPO is sent to consumers
	Why	CPO has thickened so that it requires heat from the boiler to convert it into its original form.
	How	Determine the right temperature and cleane the storage tank regularly

Then, the recalculation of standard time estimation is carried out. The recommendation of improvement reduction of standard time can be seen in Table 8.

Table 8
Recommendation of Improvement and Reduction of Standard Time

Waste Activities	Standard Time	Recommendation of Improvement	Estimated Standard Time After Improvement
FFB temporarily stacked while waiting for empty lorry from Threshing station	51,65	1. Implement a First In First Out (FIFO) system. 2. Lorry filling must be full according to capacity. 3. Minimize susceptible fruit. 4. Add more lorries	25,82
The lorry waiting to be lifted using Hoisting Crane	6,50	1. Implement a First In First Out (FIFO) system. 2. Adjust the sling correct 3. Operator must be agile.	3,25
Dirty CPO deposited in Sand Trap	33,78	1. The temperature must be set according to the standard (95^oC-115^oC) 2. Dispose of sand regularly for 4 hours. 3. Added a diluent tank.	16,89
Pure CPO waiting to be loaded into delivery trucks	150	1. Determine the correct temperature. 2. Cleaning the storage tank regularly	75

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Based on the reduction of the standard time after improvement, the number of Manufacturing Lead Time was reduced to 1069.73 minutes. Calculation of Process Cycle Efficiency value after improvement is as follows:

$$\text{Process Cycle Efficiency} = \frac{\textit{Value Added Time}}{\textit{Manufacturing Lead Time}} = \frac{793{,}04}{1069{,}73} = 74\%$$

F. Future Value Stream Mapping Establishment

The purpose of this mapping is to compare the Future Value Stream Map (FVSM) and Current Value Stream Map (CVSM) after corrective action. The Future Value Stream Map (FVSM) for the Crude Palm Oil (CPO) production process can be seen in Figure 2.

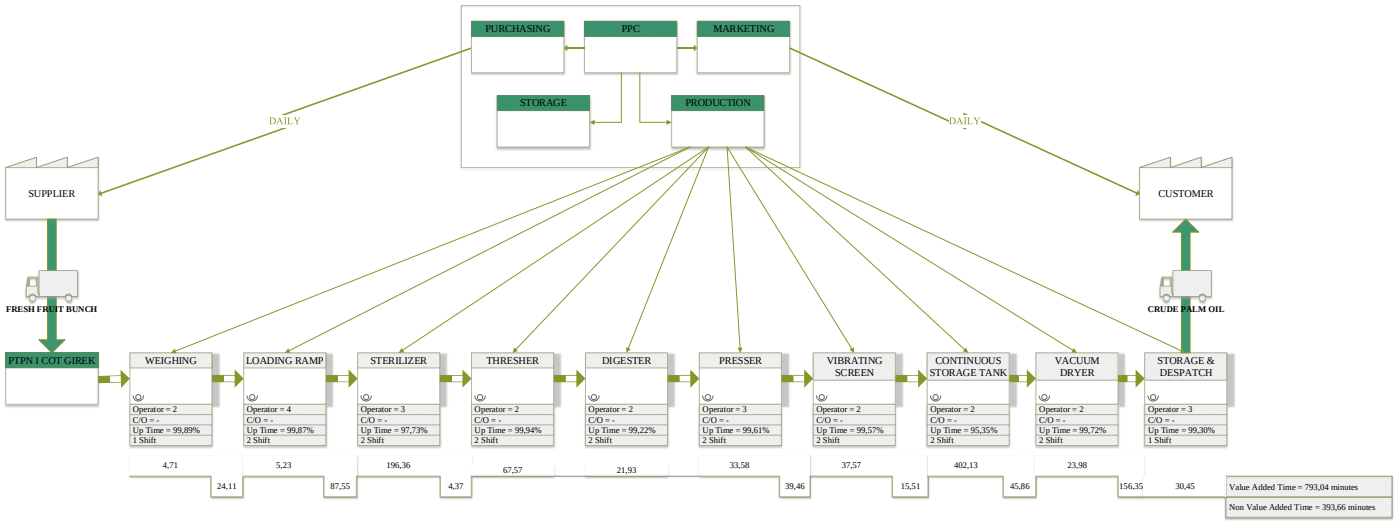

Fig. 2 Future Value Stream Mapping

G. Comparison of Current Value Stream Mapping Future Value Stream Mapping

Table 9 would exhibit a comparison of lead time, value added time, non-value added time and process cycle efficiency percentage between current state mapping and future state mapping.

Table 9
Comparison of CVSM and FVSM

Ratio	CVSM	FVSM
Lead time	1186,70 min	1069,73 min
Value Added Time	793,04 min	793,04 min
Non Value Added Time	393,66 min	276,69 min
Process Cycle Efficiency	67%	74%

VI. CONCLUSIONS

The research is limited only to the determination of improvement recommendations, not to the implementation of the recommendations. Based on the Value Stream Mapping design, 11 activities were found to be wasteful or non-value added along the CPO production process but only 4 activities that could be taken corrective action. After designing the improvements, it was found that the Manufacturing Lead Time decreased from 1185.70 minutes to 1069.73 minutes and the Process Cycle Efficiency value increased from 67% to 74%.

Based on the 5W+1H analysis, there are 4 waste activities analyzed, namely the FFB temporarily stacked while waiting for empty lorry from Threshing station, the lorry waiting to be lifted using a hoisting crane, CPO deposition in the sand trap, and CPO in the storage tank waiting to be filled into the delivery truck. The causes of these processes are analyzed and recommendations for improvement are given to make the production process more effective.

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The production department should immediately implement improvements to non-value added activities and measure Manufacturing Lead Time and Process Cycle Efficiency on a scheduled basis.

REFERENCES

1. Capital, Mekong. (2004). Introduction to Lean manufacturing, Vietnam: CRC Press.
2. Daman, A. and Nusraningrum, D. (2020). Analysis of Overall Equipment Effectiveness (OEE) On Excavator Hitachi Ex2500-6. *Dinasti International Journal of Education Management and Social Science*, *1*(6), p.847-855.
3. Heizer, Jay and Barry Render. (2009). Manajemen Operasi. Jakarta: Salemba Empat.
4. Gasperz, V. 2011. Lean Six Sigma for Manufacturing and Service Industries. Jakarta: Gramedia Pustaka Utama.
5. Rother, M. and Shook, J. (2009). Learning to See VSM to Create Value and Eliminate Muda. Lean Enterprise Institute: Cambridge.
6. Sandroto, I.V, Kurniadi. (2007). Value Stream Mapping. *Proceeding International Seminar on Industrial Engineering and Management*, ISSN: 1978-774X.
7. Wignjosoebroto, Sritomo. (2006). Pengantar Teknik dan Manajemen Industri. Guna Widya: Surabaya.