

# Reducing Production Waste Using Lean Manufacture

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**Abstract**—Currently, in globalization era, business competition in the fertilizer industry in Indonesia is very tight. This spurred the company to continue improving production results in terms of quality, quantity, price, and timeline of delivery to its customers. PT. JM Fertilizo (PT. JMF) is a company engaged in the processing of mining products that produce fertilizer for export purposes. One of the products delivered by PT. JMF is fosfat powder and Granule fertilizer. The company data shows in 2016 the company able to produce 550 tones / month and in 2017 able to produce 350 tones / month. Furthermore, there are still many products that can't meet customers requirement and several delays in product delivery. This problem causing inefficiency and decrease in production capacity. Therefore, this study was conducted to reduce the problems that exist in PT. JMF. The study which applied tools from Lean manufacturing, named value stream mapping and root cause analysis method has a conclusion that inappropriate process and waiting are the most dominant waste. The suggestions from this study are improving information flow, training production operators, and investing in new machinery.

**Keywords**— Root Cause Analysis, Value Stream Mapping, Waste.

## I. INTRODUCTION

COMPETITION on both service and manufacturing industries are rapidly growing. This triggered both service and manufacturing companies to continuously improve their production, whether in terms of quality and quantity. One of the common problem that appear in this already competitive industry is the needs to produce a product with higher quality using as small as resources possible. This problem make manufacture industry must give a guarantee to make the best product possible for consumer. The transformation of market demand need the added value and big improvement that caused an impact in the production process. Company performance must be improved to gain high level of productivity.

Facing the global free markets, manufacturing companies are required to increase their competitiveness by producing goods effectively and efficiently, from upstream until the downstream production. Local manufacture industry not only facing their surroundings company but also with other companies from developed country. With the improvement of competition to create competitive product, so the consumer will take benefit to choose more desirable product. Consumer will choose the higher quality product, with cheaper price and on time delivery.

The improvements of production process efficiency that many companies do is one of the finest strategy to facing the decline of market demand. Efficiency is the company capability to eliminate or decrease waste from their resources

to produce a product with as high as possible standard. The good companies can be produce the higher quality product with minimal resources. To reach high level of efficiency companies must doing refinement to fix operational mistakes that caused waste or loss.

The application of Lean Manufacturing will help industries to minimize production cost that effected on product price so will also make an impact competition with other companies [1]. Consumer will only pay the value of product and will not pay non added value activity in production process. So it needs production process that can eliminate non effective and non efficient activities with concerning about value added and non value added. The waste that called seven waste including overproduction, waiting, transportation, inefficient process, work in process, unnecessary motion, and defective product [2].

PT. JM FERTILIZO is a company engaged in mining, excavating, processing and distributing fertilizers for local and international markets. The main commodity produced by PT. JM FERTILIZO is Phosphate. Company's data shown a decrease in production output which in 2016 was able to produce 550 tons / month, but in 2017 the production output was 350 tons / month. In addition to the decreasing production output, there are many products that are oversized or undersized (not in accordance with customer specifications) and also there are delays in the items received by the customer. This causes inefficiencies and decreases the production capacity. Other than that, it also causes the delay in sending export fertilizer has resulted in inventory or buildup. With the excess time due to late delivery, this will increase production costs indirectly. Based on the explanation above, the company needs a solution to be able to reduce waste. Therefore we need a study in lean manufacturing concepts (Value Stream Mapping Tools), researchers will show the existence of Non Value Added in the implemented production system.

Efficiency is the key indicator for department to decrease or eliminate waste in a whole process. To improve efficiency, production department must doing sustainable refinement so that can decrease waste in production process [3]. The waste that caused from inefficient laborer in production process, wrong shipping schedule that not match with production schedule, pile of raw materials that not yet processed, off specifications product such as over sized or under sized, slow engine operation by laborer, all of that problem will be effected on the next process.

Based on above explanation, we conclude that there are still non value added activity that will increase production cost. The company needs solutions to decrease waste. So it will need research based on Lean Manufacturing concept

(value stream mapping tools) researcher will shows Non Value Added in production process. Researcher will also give refinement solutions to eliminate waste.

## II. METHOD

### A. Research Methodology

Research methodology will separate into some systemic step starting from problem background, the reference of literature review, until the completion of research in the from conclusion and suggestion. The explanation from research's steps shows on flowchart methodology in figure 1 is as follows:

1. Identification step and preliminary research  
This step consist of company review, problem identification and formulation, determination of research purpose, study literature, and the last's step field survey
2. Data collection step  
In this step primary and secondary data needed for this research will be collected.
3. Data processing step  
This step will process the data with corresponding tools which used in accordance with their function.
4. Conclusion and suggestion step  
This step will taken conclusion from conducted research and suggestion both for company or for next research.

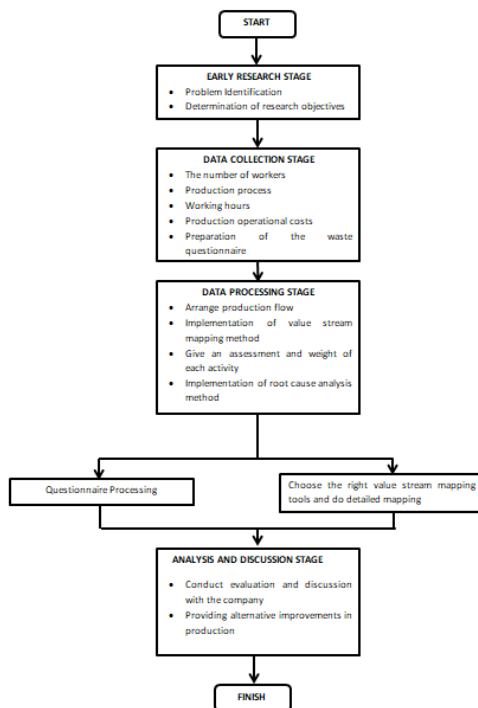


Figure 1. Research Methodology Flowchart

### B. Lean Manufacturing

Lean Method focused on removing or decrease waste and maximized any kind of activity that having added value. From the customer perspective value is anything that make customer want to pay more money for the following product or services. Minimizing waste is the key factor of Lean Manufacturing concept.

The benefit for company that implementing Lean

Manufacturing method according to is reduced lead time, reduced inventory, improved knowledge management, financial saving, less rework, less process waste, increased process understanding, and robust process [4]. The reduced waste is seven kind of waste including over production, waiting, transport, defect, motion, over processing and inventory. The implementation from the chemical company mentioned in this journal, succeed to make significant impact including:

- Reduced supply chain cycle time up to 50%
- Increased the accuracy of delivery order (quantity and quality) up to 25%
- Reduced inventory up to 30% (including safety stock toward sales forecast)

This method suitable for the company which have continuing process so the integration of operator, method, process and good management can be possible for the sake of reduced waste, that make reduced manufacturing cost. The above condition illustrated in the following figure 2.

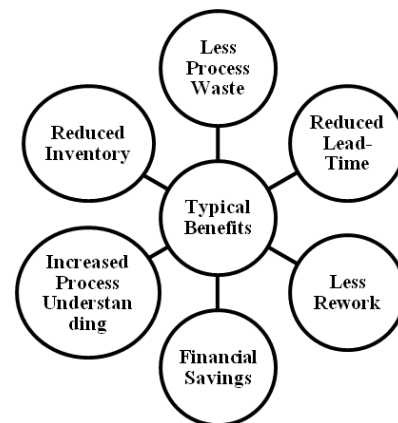


Figure 2. Benefit of Lean

### C. Value Stream Mapping

Value Stream Mapping is graphical tool used in Lean Manufacturing which help company to analyze material flow and giving information while product still in process through all business process that create value from raw material until delivered to the customer. Value Stream Mapping can visualize product flow and identified the waste then help to give priority to which problem that must be solved first. Value Stream Mapping is one of the process mapping that shows detailed material flow, information flow, operational lead-time parameter, yield, uptime, delivery frequency, manpower quantity, batch volume, quantity of inventory, setup time, process time, and all of other process efficiency [5]. Value Stream Mapping has many benefit and the main tool for Lean Manufacturing to help us analyze current business process thoroughly, so it can help us to create a vision about our desired business process, and how the business process become so efficient and free of waste. Start from here we can start some improvement project based on priority that identified from Value Stream Mapping.

Value Stream Mapping created specifically for certain product with specific demand rate. The grouping for the same process step also called family grouping. After a specific product determined, the following customer demand must be determined for give us an idea about takt time, takt time is time needed to produced a product. Several thing that will identified from Value Stream Mapping are, excessive

Table 1.  
Waste Explanation

Waste Types	Explanation
Inappropriate Processing	The process of sorting raw materials back by the company on raw materials that have been through the sorting process by the supplier
	The production process is not in accordance with the standard, many products that do not meet specifications.
	Machine operators who impose wet raw materials to put into the machine, causing damage to the engine and slowing down engine performance The production process time increases
Waiting	There is a waiting time between stations in the production process
	Machine damage often occurs Delayed work

Table 2.  
Valsat Result

No	Waste	Bobot	Valsat						
			PAM	SCRM	PVF	QFM	DAM	DPA	PS
1	Waiting	3.4	30.6	30.6	3.4	0	10.2	10.2	0
2	Overproduction	1.9	1.9	5.7	0	1.9	5.7	5.7	0
3	Defect	1.6	1.6	0	0	14.4	0	0	0
4	Unnecessary Motion	1.7	15.3	1.7	0	0	0	0	0
5	Inappropriate Processing	3.6	32.4	0	10.8	3.6	0	3.6	0
6	Unnecessary Inventory	1.5	4.5	13.5	4.5	0	13.5	4.5	1.5
7	Inefficiency Transportation	1.4	12.6	0	0	0	0	0	1.4
	Total		98.9	51.5	18.7	19.9	29.4	2.4	2.9

Table 3.  
Process Activity Mapping Result

Aktivitas	Jumlah Aktivitas	Persentase (%)	Waktu (menit)	Persentase (%)	VA	NVA	NNVA
Operation	9	50	1578	60.25	810	178	599
Transport	5	27.78	246	9.39	73	150	23
Delay	1	5.56	243	9.27	243	-	-
Inventory	1	5.56	145	5.53	145	-	-
Inspection	2	11.11	407	15.54	407	-	-
Total	18		2619		1678	328	622

inventory in certain process, high amount of scrap, low uptime, oversized batch size, not enough information flow, too long waiting time, and time efficiency of all business process.

Value Stream Mapping required for validate operational data directly to discussed with workers directly to make sure data actuality. Value Stream Mapping will help to improve business process thoroughly and make it so efficient. The purpose of Value Stream Mapping are to show us the cause of waste and eliminate it with the implementation of future state value stream that can be realize in relatively short time [6].

*D. Root Cause Analysis*

The first step to identify risk is analyzing from failure or waste that happen in production process sequences. Root Cause Analysis is a method which determines the relationship between cause and effects in one problem or failure [7]. This method can be used on every problem even the root cause is not defined. There are two techniques in applications of Root Cause Analysis method. The first one is 5W technique and the second one is Fishbone Diagram. Root Cause Analysis using static, quantitative, and qualitative approach to identify and determine root cause from 5W technique [8].

III. RESULTS AND DISCUSSION

In the concept of lean manufacturing there are 7 types of waste which are then input into the questionnaire distributed

to 10 people who are directly involved in the fertilizer production process. The choice of answers is in the range of values 1 - 5, value 1 means that waste rarely occurs and value 5 means that waste often occurs. The most critical type of waste is waste which has the highest value than others, where the value is obtained from the average given by the respondent.

Base on the questionnaires, inappropriate processing waste has the highest value compared to others, which is equal to 3.6 so that it can be interpreted that inappropriate processing is the type of waste most often encountered in the phosphate fertilizer production process, which is then followed by waiting waste.

Value Stream Analysis Tools or VALSAT is a method used to select the most appropriate tools to identify waste in the value stream mapping. The selection of tools is based on the values of each tool, where the values are derived from the calculation between the matrix VALSAT and the weight of each type of waste.

Based on Table 2, it is found that the tools that have the highest VALSAT value are PAM with a value of 98.9 or can be interpreted that these tools are effective to identify and eliminate waste that is in the process of making Phosphate fertilizer by PT. JM Fertilizo.

Process Activity Mapping or PAM is a method used to describe all production activities at PT. JM Fertilizo and eliminate activities that are lacking and not important so that they get effective and efficient activities. There are five categories of activities on PAM tools that are operation,

transport, inspect, storage, and delay. In addition, there are also four factors that are used as the basis for making improvements, namely the number of operators, operational time, and the distance from one activity to another. The following is the result of the activity mapping process found at PT JM Fertilizo.

Based on PAM, it can be seen the activities carried out during the fertilizer production process at each production station. Distance and time are calculated by surveying the location and using Google Maps with an accuracy of 5 meters. Every activity carried out involve the operator with or without the help of equipment / machinery, distance, and length of time of an activity. Existing activities are then categorized based on the type of activity as previously explained, besides, it is also determined whether the activity is included in activities that are Value Added (VA), Non Value Added (NVA), or Necessary but Non Value Added (NNVA).

Based on the existing results from PAM, then recapitulation will be carried out as in table 3. Can be seen in the table, that the total time needed in the process of phosphate fertilizer production by PT. JM Fertilizo is 2619 minutes with a total of 18 types of activities that are categorized as activities of type of operation, transportation, delay, inventory, inspection where each type of activity has a number of 9, 5, 1, 1, and 2.

After mapping the production activities found at PT. JM Fertilizo, then describes the production process into the current state value stream mapping. The purpose of the VSM is to show the source of waste and eliminate it by implementing the future state value stream that can be realized in a short period of time.

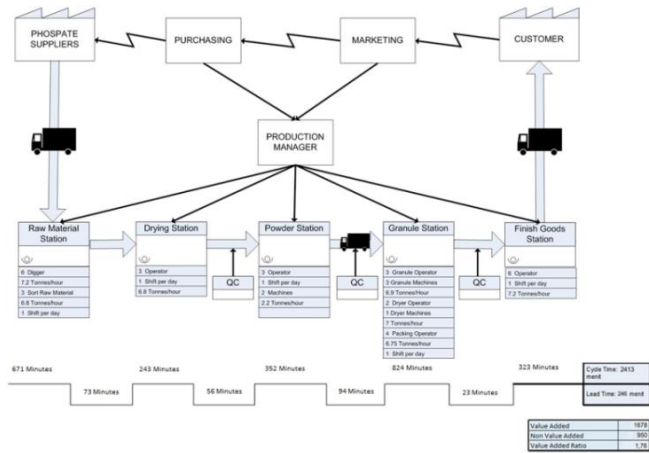


Figure 3. Current Value Stream Mapping on PT JM Fertilizo

Based on the data that has been mapped on the current value stream mapping according to Figure 3 in one production process the total cycle time is 2,413 minutes or 40.21 hours with a lead time of 246 minutes or 4.1 hours. In addition, from the current value stream mapping it can be seen that the company has problems including the following:

1. Unbalanced production speed at each station in the production process which causes a bottleneck if the previous station's production speed is higher than the station's production speed thereafter, and by not providing buffers to overcome the accumulated work in process.
2. The occurrence of obstacles in the production process which can be seen in Figure 4 which is indicated by a purple circle, where there are activities waiting in the production process. This is due to the location of one

station with the other station placed in a different location.

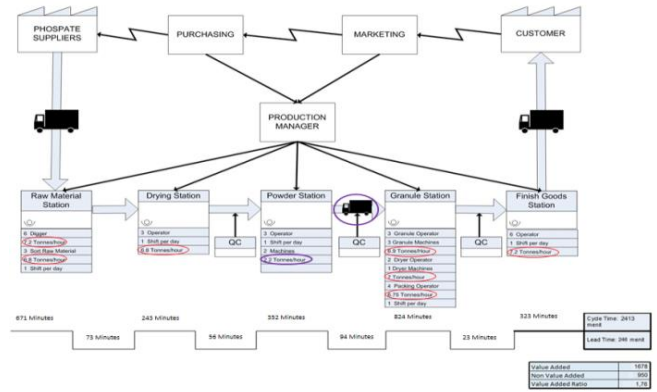


Figure 4. Problems on Current Value Stream Mapping

After the results were obtained that included critical waste at PT. JM Fertilizo is inappropriate processing and waiting. The following will be given a waste analysis with root cause analysis for each critical waste.

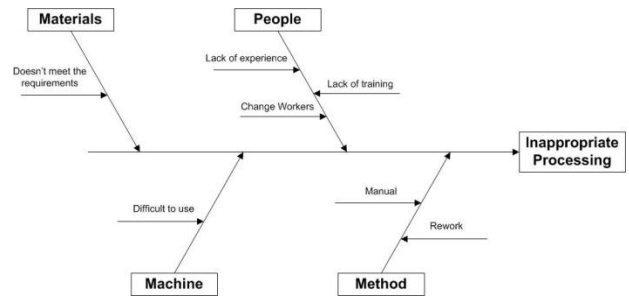


Figure 5. Fishbone diagram from inappropriate processing waste

For waste that caused by inappropriate process in sorting process caused by the company desire to make sure the materials from supplier are good and the different of sorting standard that company and suppliers have. Inappropriate processing waste caused by engine operators because the company not socialize the SOP properly, also the SOP are not available in working area so engine operators can't access it in any time, or neglectful engine operators and high production target also caused the waste

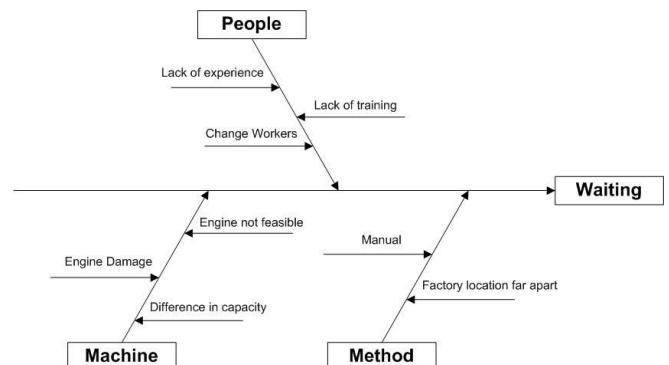


Figure 6. Fishbone Diagram Waste Waiting

Based on figure 6, we conclude that waste waiting caused by 3 factor including, human factor, method, and engine. In human side waste waiting caused by engine operators that not understand the SOP, it will increase processing time. Second factor is method, existing conditions shows that there is different station location. This difference make distance between production station. Plus there is station that far away from previous station. This distance make an impact in production speed that not even between stations. In some stations also still using manual process that causing

differences in production speed. The third factor is the engine, waste waiting also caused by the difference of capacity between the engines, also the engine damage, and old engines will also decrease production speed.

Based on the results of Root Cause Analysis (RCA), the root causes of each waste that occur in the production floor of fertilizer production are obtained. The next step is to make an alternative improvement scheme to create a production floor that runs effectively and efficiently. The following is an alternative improvement scheme made.

Table 4.  
Proposed Improvement

No	Waste	Root Cause Analysis	Proposed Improvement
1	<i>Inappropriate Processing</i>	The company wants to reassure the raw materials sent by the supplier. The company has different provisions with the supplier for sorting.	Improvement of communication or information flow between the company and the supplier.
		The company has not held a socialization to understand SOPs to operators SOP cannot be freely accessed by the operator or are not available in the work area The operator is being negligent or experiencing fatigue	
2	<i>Waiting</i>	Operators are pursued by production targets that must be met.	Training for operators on the production floor.
		The difference in the speed of the production process on the machine used. Engine life that has reached its lifetime. Location between different stations	

According to table 4 there are 3 refinement scheme alternatives which created to resolve the waste :

1) *Resolve the information flow*

This resolve provide a solution between the company and their suppliers so the company can ensure or review the raw materials sent by suppliers and the company also have their own rule to filter the materials. The solution for this problem is to fix the communication or information flow between them and create SOP for raw materials filtering

2) *Operators Training*

Giving training for laborers and all human resources that involved in fertilizer production process. According RCA, inappropriate processing problem caused by operators that does not have the required understanding on production's SOP, other than that there aren't printed version of SOP and frequent substitute of laborers also make them difficult to understand the SOP. Besides, operator's fatigue can make the failure probability increased. Training programs that held by company help laborer to make better understanding in production SOP. Company must make printing version of their SOP and post it in every production station. Training given by company used to improve laborer competition in every job description, especially at production floor. This treatment will help operator to aware about every restriction in their job so it will minimize failure caused by operators fatigue.

3) *Investing in new machine*

Company can buy a new machine as a solution to facing a higher production target, higher production speed produce by newer machine, and old machine that already reach their lifetime limit. Tight schedule plus minimal understanding of production SOP can caused fatal damage in production machine. Unscheduled maintenance for existing machine also increase machine failure probability. Failure of production machine will decrease production capacity and overall will decrease company productivity also. Also there is production speed difference between powder Station and granule station will cause bottleneck. Bottleneck also can decrease productivity. Company must aware about their production machine lifetime, if it already reach their lifetime will be better if they buy new one

After calculation, the existing conditions and improvements to the fertilizer production process by PT JM Fertilizo can be compared. The repair condition in question is the condition where the production floor is precisely at the powder station, with the addition of a powder machine with a capacity of 10 tons / hour and a conveyor machine at the raw material station as a substitute for manual work so that the work is completed faster. Comparison is done by looking at two aspects, namely in terms of output and sales revenue. In terms of output, the existing conditions of the production process of PT JM Fertilizo produce 350 tons every month, after improvement, output increases to 603.4 tons per month. An increase of around 72%. While revenue from fertilizer sales also increased. The percentage increase is also the same as the previous aspect. This is because income is directly proportional to the output or output of the company.

IV. CONCLUSION

Based on the results of calculations and analyzes that have been carried out, the type of waste or waste that most often occurs in the process of fertilizer production by PT JMF is inappropriate processing and waiting. The two types of waste were identified by interviewing operators who were directly involved in the production process and carried out in-depth analysis using the Process Activity Mapping method and Value Stream Mapping method. The main cause of inappropriate processing waste is frequent reworking on the production floor plus a lack of understanding of machine operators on applicable SOPs. While the main cause of waste waiting that often occurs is the existence of a significant gap or difference between the engine capacity at station one and another production station.

There are three proposed improvements submitted and accepted by the company as follows:

- Improve the process of information flow between the production division and suppliers and make clear SOPs.
- Conduct training for all production staff so that they can run production machines in accordance with the rules in the guidebook.

Invest in machinery so that the production process can run continuously so that it can produce the desired production capacity.

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