Lean Manufacturing: Waste Analysis in Crude Palm Oil Process

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Abstract. Lean Manufacturing is an approach to system efficiency by reducing waste. Companies need to identify value added activities on products, non-value added activities (waste) must be eliminated to decrease the production lead time. Palm Oil Industry produces 2 main products namely Crude Palm Oil and Kernel Palm Oil. This paper describes the waste analysis occur in the palm oil production process. Waste management activities are identified along the production process flow. Then investigates the waste root causes occur the most. The result obtained is value added activities of 47%, non-value added activities of 13%, and necessary non value added activities of 40%.

1. Introduction
The production process is a stage for converting inputs into desired outputs. This production process involves all the resources are owned by a company. Increasing business competition and high demands from consumers requires companies capable to manage production processes more efficient and effective and produce high quality products. Lean manufacturing is a method to increase responsiveness through efforts to reduce waste, continuous improvement and cost reduction [1].

A company with a lean system is the goal that the company wants to achieve. Because lean system have many advantages from efforts to reduce and eliminate waste [2]. Lean Manufacturing is a production activity focuses on reducing waste in all aspects of the company's production activities [3,4]. Lean manufacturing is a technique allows work carried out without a problem. This method will eliminate wasteful activity by balancing the number of work steps, allowing the product to be consumed directly to the next step, step by step until it’s done [5,6].

Waste is any work activity does not provide value added throughout the process flow in the process of converting inputs into outputs. Waste are divided into two types, namely type 1 and type 2. Type 1 is a waste does not provide value added along the production flow but this activity cannot be avoided for various reasons. Type 2 is a waste that does not provide value added and must be eliminate immediately [7].

Lean Manufacturing is a systematic approach to eliminate waste and processes converting. This is done by identifying and reducing waste by continuous improvement [8]. Lean Manufacturing encourages the flexibility creation in production systems reduce unnecessary inventory, increase knowledge about the production process, save cost, reduce defects so that quality increases, reduce production lead times and reduce waste [1]. Lean manufacturing aims to increase productivity, improve product quality and manufacturing cycle times, reduce inventory, reduce lead times and eliminate manufacturing waste [9]. Many studies have applied lean principles in various industries. In the
manufacturing industry especially applied the implementation of lean manufacturing and concurrent engineering has been carried out on the assembly production floor in the tractor industry [10].

Another implementation carried out in the plastic injection molded auto-parts industry showed that lean manufacturing increase productivity by up to 25%. Lean manufacturing has also been used in industries produce Fast Moving Consumer Goods (FMCG) products. The lean approach has also been carried out in the service industry namely Indian Software Services Firm [11], government agencies to improve efficiency and provide better service quality to their customers [12], banking industry [13], and local public service provider councils [14]. This paper aims to identify and analyze the waste occurs throughout the palm oil production process.

2. Methodology

There are five Lean Principles, namely 1) Value Determination. Value only defined by key customers. Values are distorted by preexisting organizations, especially engineers and experts. They add to the complexity which is not attractive to customers. 2) Identification of Value Streams. Value Stream is all actions needed to bring a product to the customer. 3) Flow. Eliminate the department that runs out a large number of single task processes. 4) Attraction. Let customers attract or request products from you. 5) Pursue Perfection. There is no end to the process of time, space, costs, and errors reduction [15].

To implement Lean Manufacturing can be done with several stages [16] namely (a) problem identification, (b) observation, (c) waste analysis to see possible causes and find the root causes of waste problems with cause and effect diagrams, and (4) action. The problem faced by the factory is that there is still waste causes production is not optimal. Then it is necessary to observe waste with value stream mapping to identify the waste. The application of lean manufacturing with value stream mapping has been successful in reducing waste and total lead time [17]. Fishbone diagram to analyze the causes of waste.

3. Result and Discussion

3.1. Problem Identification

The palm oil industry produces 2 main products, namely crude palm oil and kernel palm oil. The palm oil industry is still experiencing problems related to the lack of supply of fresh fruit bunches, and high manufacturing lead time due to activities that do not provide value added. At the sterilizer/boiling station where the loading ramp capacity (each door has a capacity of 16,5 tons) is not proportional to the truck capacity (each truck capacity is 3,5 tons). Transfer of lorries at the sterilizer station must use a capstand and transfer carriage to enter the sterilizer to be boiled and do the same thing when lorries containing boiled FFB must be pulled using a capstand and transfer carriage move to the tippler machine. Each machine operator often leaves the machine during the production process for other purposes. There are still many wastes occur along the production flow causing high manufacturing lead time. Lean manufacturing is used to identify and analyze the waste occurs along the value of the palm oil production process flow.

3.2. Observation

Observations were made on the palm oil industry with the determination of 10 observations for each activity in a 5 minutes cycle or less and 5 times of observation for each activity in the 5 minutes cycle of more than 5 minutes. The results of observations will be tested for uniformity and normality. The processing time of each activity is the normal time obtained from the calculation stages of cycle time and standard time.

Manufacturing Lead Time is the time required to carry out the production process from the beginning to the end. Calculation of Manufacturing Lead Time is done by adding up the entire work process time consisting of 20 work processes. Value Stream Mapping which is equipped with total cycle time information which is categorized in the non-value added activity (NVA), necessary non-value added activity (NNVA), and value added activity category (VA).
Table 1. Classification of Palm Oil Production Process Activities

| No. | Activities                                                                 | Time (sec) | Category |
|-----|-----------------------------------------------------------------------------|------------|----------|
| 1   | FFB (Fresh Fruit Bunches) weighed in Weighbridge                            | 44         | NNVA     |
| 2   | FFB transfer to sortation station                                           | 72         | NNVA     |
| 3   | FFB collection to disassembly and sorting                                   | 2.753      | NNVA     |
| 4   | FFB sortation inserted into the Loading Ramp                                | 1.674      | NVA      |
| 5   | FFB inserted into the truck                                                 | 1.133      | NNVA     |
| 6   | Truck is pulled into sterilizer                                             | 559        | NNVA     |
| 7   | Sterilizer process to produce ripe fruit                                    | 5.747      | VA       |
| 8   | Truck is pull out                                                           | 1.069      | NVA      |
| 9   | Truck of capacity fulfilment                                                | 4.196      | NNVA     |
| 10  | Ripe fruit is inserted into the thresher machine to separate the palm seeds with empty bunches | 3.531      | VA       |
| 11  | Palm seeds digest using a digester machine                                  | 1.040      | VA       |
| 12  | Palm seeds is pressed into the presser machine to produce dirty CPO and core | 4.178      | VA       |
| 13  | Dirty CPO sedimented into Sand Trap                                         | 2.153      | NNVA     |
| 14  | Dirty CPO is filtered using the vibrating screen                            | 1.055      | VA       |
| 15  | Dirty CPO is temporarily collected in Crude Oil Tank                       | 1.680      | NVA      |
| 16  | Dirty CPO is separated between oil, water and sludge using Continuous Storage Tank | 965        | VA       |
| 17  | Oil and water are sedimented in the Pure Oil Tank                           | 2.090      | NNVA     |
| 18  | The oil is inserted into a Vacuum Dryer Machine to separate the oil from the water content to obtain pure CPO | 1.205      | VA       |
| 19  | Pure CPO is streamed into Storage Tank for storage                          | 413        | NVA      |
| 20  | CPO fulfillment in trucks                                                   | 2.245      | NNVA     |

TOTAL 37.802

Table 1 shows the manufacturing lead time of the palm oil production process which consists of 20 activities of 37.802 seconds. These activities include of 7 value added activities (VA), 4 non value added activities (NVA), and 9 necessary non value added activities (NNVA). The proportion of each VA, NVA, and NNVA activity towards manufacturing lead time can be seen in Figure 1.

Figure 1 shows the percentage of each activity towards the manufacturing lead time of the palm oil production process. About 53% of activities carried out are non-value added activities and only 47% are included in value added activities. However, 40% of non-value added activities is difficult because it is needed and support the production process to achieve customer value. But these activities can be
reduced. While the other 13% is non value added activities that can be eliminated because it includes waste. Value stream mapping includes current state mapping and future state mapping. Current State Map is a description of the production process flow in the company which includes material flow and information flow. Value stream mapping process of palm oil production can be seen in Figure 1.

Figure 2. Value Stream Mapping Production Process in the Palm Oil Industry
All stages/processes of actual palm oil or Crude Palm Oil (CPO) are described in Value Stream Mapping (VSM). This aims to facilitate the process of non-value added activities identification throughout the production process. So, based on the observation results on the production floor, do seven identification. The identification results are as follows.

3.2.1. Transportation Waste
Transportation waste can be identified by looking at there is material movement or not, work in process, or finished products on the same flow. In general, the factory layout has been set well, but there is still a work in process flow that goes through the same flow. Such as the sterilizer station there are still waste activities. Where at the FFB inserted into a truck to be boiled in a boiling machine moment. The truck flow surrounds the entire area of the sterilizer station. We can see that in the figure below.

Figure 3. Boiling Process Flow
3.2.2. Inventory Waste
Inventory Waste in this CPO industry is the CPO bottleneck occurrence or storage of CPO production materials in the factory for a long time. At this time the factory has 2 storage tanks which are used as a CPO storage. As a result, CPO has experienced thickening or sedimentation in a storage tank with a capacity of 2000 tons. At the time of the CPO pickup by the truck transportation certainly takes a very long time. Because to overcome the thickening of CPO required heat from a very long Boiler. You can say there is still a storage waste in the factory.

3.2.3. Motion Waste
In general the movement activities on the production floor at the factory has been run smoothly and systematically. This is because of Standard Operating Procedures (SOP) usage are made perfectly to help every step of the work on the production floor. All operators on the production floor also have their respective roles to carry out the same work in a sustainable method. Each operator works according to their expertise, with facilities and supporting equipment have been schematically arranged on the production floor. But there are also operators who ignore the Standard Operating Procedures (SOP) and leave the machine without a replacement operator observation on the machine.

3.2.4. Waiting Waste
Waiting waste is a significant problem in the factory supply chain. At the sorting station, the press and CPO fulfilment stations are experienced waiting waste. The raw materials of Fresh Fruit Bunches do not arrive on time and in a different quantities. Sorting stations with collect FFB raw materials collection for unloading and sorting first. The press station had experienced damage so that production activities experienced a temporary delay. When CPO fulfilment in the truck transportation experienced waiting waste because the CPO has sedimentation/thickening so that it requires heat from the boiler for the CPO fulfilment process.

3.2.5. Over processing Waste
Overproduction process activity in factory is rarely happen. There is no unnecessary process in the process of producing FFB into CPO products and no repetition of processes is found. Every activity in the production process has been arranged and arranged properly with the existence of Standard Operating Procedures (SOP) guide employees when working on the production floor.

3.2.6. Overproduction Waste
Overproduction waste in general it can be interpreted as something related to the overproduction resulting in the finished products bottleneck or semi-finished products exceed the factory capacity which causes storage for a long period of time. Production results produced will be taken by a Group subsidiary to be managed into oil and launched to the market, so it can be said that the factory does not have overproduction waste.

3.2.7. Defect Waste
Defect waste is insignificant, because the raw materials used such as dura and tenera palm oil must be in the specified quality standards and employees at the sorting station must join the training. Of course this is affect the quality standards of CPO products. In the production process the quality level of CPO products is inspected by laboratory employees and factory and also maintaining and guaranteeing the quality level of CPO production.

| Table 2. Quality of CPO Production |
|-----------------------------------|
| CPO Production | Actual | Standard |
| Moist CPO      | 0.176  | 0.2      |
| Dirt CPO       | 0.019  | 0.02     |
Table 2 shows the quality standards applied by the company and the actual achievements of the production process. Crude Palm Oil production still has a FFA value greater than the standards set by the company, but for the moist level, CPO and DOBI dirt is in the standard limits. High levels of FFA in CPO are influenced by the length of FFB waiting time to be produced and the quality of FFB.

3.3. Waste Analysis

Fishbone Diagrams are tools used to identify and place the root causes of waste problems systematically. A causal diagram (fishbone) for obstacles occur in the production process of palm oil can be seen in Table 3.

| Problem          | Causes                                           | Roots of Problem                                      |
|------------------|--------------------------------------------------|-------------------------------------------------------|
| Transportation   | Man: Operators are slow at work                  | Operators are not responsive                          |
| Waste            | Operators are not responsive                      | Fatigue operators                                     |
| Machine          | Low capacities                                   |                                                       |
| Method           | Only one truck of pouring machine                |                                                       |
|                  | SOP misunderstanding                             |                                                       |
|                  | Attention lack of work instructions              |                                                       |
|                  | SOP is not implemented properly                  |                                                       |
| Inventory        | Man: Operators do not supervise intensively      | Operators do not supervise intensively                 |
| Waste            | Fatigue operators                                |                                                       |
| Machine          | Long distance of storage tank                    |                                                       |
| Method           | The pump is not in ideal condition               |                                                       |
|                  | CPO collection schedule is missing               |                                                       |
|                  | SOP ignorance                                    |                                                       |
| Motion           | Man: Non intensive supervision                   | Non intensive supervision                             |
| Waste            | Fatigue operators                                |                                                       |
| Machine          | Temperature of boiling machine                   |                                                       |
|                  | Body of boiling machine close to the operator’s  |                                                       |
|                  | station                                         |                                                       |
| Method           | SOP ignorance when production process            |                                                       |
|                  | Operator do not understand of SOP                |                                                       |
| Environment      | Hot temperature of boiling work area             |                                                       |
| Waiting          | Man: The sorted FFB is not separated immediately | The sorted FFB is not separated immediately            |
| Waste            | Damage trucks are not removed                    |                                                       |
| Machine          | Loading ramp capacities over the truck capacity  |                                                       |
| Method           | Do FFB bottleneck                                |                                                       |
|                  | The quality of FFB inserted is not standard      |                                                       |
|                  | FFB delay                                        |                                                       |
|                  | CPO experiencing sedimenting/thickening          |                                                       |

Table 3 shows the problem analysis for each waste found by describing the problem roots. After it is known that the cause of the waste occur so that the non-value added does not change, then next actions will be made to reduce the non-value added time based on the analysis of the root cause discovered. Based on the root causes described above, corrective action plans can be made to minimize waste.
4. Conclusion
At the palm oil factory, activities occur include value added activities by 47%, non-value-added activities by 13% and necessary non value added activities by 40%. In running its production, the palm oil industry is still experiencing waste, namely Transportation Waste, Inventory Waste, Motion Waste, and Waiting Waste. Every waste is searched for the root cause of the problem by using a fishbone diagram.

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