Lean Manufacturing Approach to Minimize Waste in The Process of Sorting Palm Oil Using the Value Stream Mapping Method

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Abstract. This research uses lean manufacturing approach and mapping the production line of a product which includes material and information from each work activity using value stream mapping method to minimize waste. Problems faced by oil palm companies can be seen in more detail in the sorting process. The company does not realize that there are many ways of working that can be improved to become more effective and efficient, from checking to grouping the quality standards of palm oil. The sorting activities are carried out from weighing FFB to selecting the quality of oil palm. The results of this study showed that the value-added activity was 69.9920863 with a process cycle efficiency rate of 27.392122%. After repairs were made, it was found that the activity of moving the palm fruit to the sorting station, the palm fruit waiting to be unloaded from the truck, the palm fruit being unloaded and sorted from the truck in the palm sorting process is an activity that has no added value, so it needs to be improved. The improvement results show an increase in process cycle efficiency to 46.909592%.

1. Introduction
Based on data from the Directorate General of Plantation Ministry of Agriculture, it was noted that oil palm land in Indonesia reached 14.03 million hectares, or an increase of seventeen percent [1]. Competition in the industrial world is growing rapidly, competitive advantage is shown in the ability of a company to produce products on time, quality and price. The condition of Indonesian palm oil companies is not very encouraging, because there are many problems that occur, one of which is the constant price of oil palm or changes according to market conditions and government regulations. The condition of the company is demanded to get optimal market opportunities. So, the company grouped the quality level of palm oil based on ripe fruit, raw fruit, rotten fruit, long block, small fruit and empty fruit. Good quality will only be obtained if the entire production process takes place optimally. The optimal situation requires all waste to be minimized or even eliminated.

In oil palm processing companies, the problem that often occurs is the palm oil sorting process. Companies do not realize that there are still many ways of working that can be improved to be more effective and efficient. The amount of waste is in the sorting process, where in the process there are five activities, namely weighing the palm fruit, moving the palm fruit to the sorting place, waiting for the loading and unloading of the fruit from the truck, loading and unloading and sorting fruit from the truck, and the sorted fruit is put into the loading ramp door. The sorting activity carried out by
operators manually with traditional tools causes many problems, such as long truck queues, piles of raw materials, so that it has an impact on product quality and productivity which will affect company profits. To overcome this, lean concepts are needed with the value stream mapping method to map the production lines of a product which includes material and information from each work activity.

The concept of lean manufacturing with the value stream mapping method has been widely applied in various fields, such as the colour industry [2], healthcare industry [3], automotive industry [4-5], assembly line industry [6-7], and small medium enterprises [8-9]. In addition, several previous studies have also applied the concept of lean manufacturing with the value stream mapping method in the palm oil processing industry [10-11]. This study identified waste in the palm oil processing production process, there were four work stations that experienced waste, namely sorting work station, ramp loading work station, sterilization work station, and pressing work station [12].

The purpose of this research is to identify waste in the oil palm sorting process using the value stream mapping method, and provide input in the form of efforts to improve waste reduction in the oil palm sorting process through a lean manufacturing approach.

2. Method
This research was conducted at the palm oil mill of PT. Karya Tanah Subur located at Aceh Province, Indonesia. Waste that occurs in the process of sorting oil palm will be the object of research. Figure 1 shows the stages carried out in the study, and displayed in the form flowcharts of research.

![Flowchart of research](image-url)
The stages of data processing carried out in this study are:

- Identify the data flow about waste in the company,
- Create a current state map from the data that has been obtained,
- An improved analysis of the current state map is carried out by identifying what wastes are present along the value stream current state, and
- Create a map of the future state, which is a picture of the state that the company wants to achieve in the future.

Problem-solving analysis, carried out on a map of the current state by identifying existing waste, looking for the root of the problem, and how to solve it. The stages include:

- Cycle time analysis or value stream mapping,
- Analysis of the value added time, and non-value added time of the process flow,
- Identification of waste in the oil palm sorting process
- Take time analysis
- Troubleshooting solutions
- Create a future state map

### 3. Results and Discussion

#### 3.1. Work Element Sorting Process

The elements of work activities at the oil palm sorting station can be seen in Table 1 below.

| No. | Work Element |
|-----|--------------|
| 1   | Weighing palm: weighing is done by 2 operators with different shifts weighing oil palm aims to make the company know the truck load. |
| 2   | Move oil palm to a sorting station: Operators bring weighing trucks and receipts so that they can queue for loading and sorting |
| 3   | Palm fruit waiting to be loaded and unloaded from the truck car: The car queues before the car is unloaded by the operator due to the build up of FFB. |
| 4   | Palm fruit unloaded and sorted from trucks: The palm oil is unloaded on a conveyor using a corner and an ambiguous which is done by 2 operators who sort |
| 5   | Sorted fruit is inserted into the loading ramp door: Palm fruits that have been sorted by the operator will be sent to the loading ramp door. |

#### 3.2. Standard Time Calculation

Standard Time is the time required by an operator to complete a job. In Table 2 can be seen the results of the calculation of the standard time of the palm oil sorting process.

#### 3.3. Current State Map

Making the current state map is done after standard time is obtained for each process, the steps used in making the current state map for each process category by using the standard time data for each process plus other data such as the number of operators, changeover time (C/O), scrap, uptime and available time. In Figure 2 can be seen the current state map that is equipped with material flow and information flow.
| Activity | Cycle Time (Minutes) | Rating factor | Normal Time (Minutes) | Allowance | Standard Time (Minutes) |
|----------|---------------------|---------------|-----------------------|-----------|------------------------|
| 1        | 1.3550              | 1.14          | 1.544700              | 8%        | 1.67902170             |
| 2        | 1.4100              | 1.09          | 1.243690              | 29%       | 1.75167661             |
| 3        | 15.6925             | 1.09          | 17.104825             | 29%       | 24.09130300            |
| 4        | 15.8335             | 1.12          | 17.733520             | 29%       | 24.97678900            |
| 5        | 11.0895             | 1.12          | 12.420240             | 29%       | 17.49329600            |

Figure 2 generally illustrates the flow of material and information. The main material used is Fresh Fruit Bunches (FFB) received from suppliers and gardens. Companies usually immediately process the raw materials that have been received. Meanwhile, there are two kinds of information flow within the company, namely manual information flow and electronic information flow. Manual information flow is the flow of information that occurs between managers, production supervisors, and technicians on every process that occurs on the production floor. Meanwhile, electronic information flow is the flow of information that occurs between consumers and personnel, purchasing parties and suppliers of raw materials. The electronic devices used are fax and telephone.
3.4. Process Activity Mapping (PAM)
This stage is grouped in identifying activities that have added value and those that have no added value, so it can be seen whether or not there is waste that occurs in the process of sorting oil palm. As for the process activity mapping (PAM) seen in Table 3.

Table 3. Process activity mapping (PAM)

| No. | Activity                             | Machine and Tools | Value Added (Minute) | Non Value Added (Minute) | Information                                      |
|-----|--------------------------------------|-------------------|----------------------|--------------------------|--------------------------------------------------|
| 1   | Weighing the palm fruit              | Truck Car         | 1,679022             | -                        | The process of weighing palm fruit                |
| 2   | Transferring palm fruit to the sorting station | Truck Car         | -                    | 1,75167661              | Transportation from the scale to the sorting station |
| 3   | Palm fruit waiting to be unloaded from a truck | Truck Car         | -                    | 24,091303               | The wait is due to a build of palm oil which is sorted so there is no place for palm oil to be taken down |
| 4   | Palm fruits are unloaded and sorted from truck cars | Gancu             | -                    | 24,976789               | Open the door of the truck when the palm fruit is not carefully dismantled, causing the number of dropper to fall and the operator must quote the using the screw and then sort it |
| 5   | Sorted palm fruit is loaded into the loading ramp | Conveyor          | 17,4933              | -                        | Move the oil palm from the sorting station to the loading ramp using a conveyor |

Based on Table 3 above shows that included value added activities are 1 and 5 with a total value of 19.1723177 minutes and those that include value added activities are 2, 3 and 4 with a total value of 50.8197686 minutes.

3.5. Calculating Process Cycle Efficiency
To implement lean in a production system, it is necessary to measure lean metrics. Measurement of lean metrics will provide an initial overview of the conditions before being applied to lean and if lean has been implemented then a good value change will be seen. One lean metric that needs to be measured includes the efficiency of the process cycle of a process can be said to be lean if the PCE value > 30%.

From the process activity mapping, it can be seen that the amount of time of value-added activities is 19.1723177 minutes, activities that do not add value amount to 50.8197686 minutes and the time of all activities is 69.9920863 minutes. So, the calculation of process cycle efficiency is as follows.

\[
\text{Process Cycle Efficiency} = \frac{\text{Value Added Time}}{\text{Total Cycle Time}} \times 100\%
\]

\[
\text{Process Cycle Efficiency} = \frac{19,1723177}{69,9920863} \times 100\% \\
= 27.392122\%
\]
3.6. Factor Identification Based on Cause and Effect Diagrams
Identification of the causes of waste is done using a causal diagram. A causal diagram is a tool used to determine the root cause hypothesis and potential causes for a problem. In Figure 3 you can see the cause and effect diagram.

After the process of identifying the causes of waste has been carried out, an effort is needed to improve or solve the problem. Can be seen in Table 4.

**Table 4. Problem solving actions**

| Activity | Factor | Potential Cause | Root of the Problem | Fixers |
|----------|--------|-----------------|---------------------|--------|
| Material | Excess TBS at the sorting station | Do not set a schedule for purchasing raw materials | Set a schedule for purchasing raw materials |
| Human    | Palm oil sorting at the sorting station | Negligent operator | Too much talking at work | Apply reward and punishment |
|          |        | The operator is less nimble | Lack of training | Conduct training regularly |
|          |        | Not the same operator | The level of performance varies | Conduct training regularly |
|          |        | The operator is not thorough | The absence of sanctions | Apply reward & punishment |
|          |        | Operators are not skilled in sorting | The urgency of the procedure is not understood | Provide education and socialization of TBS sorting procedures |
|          |        | The urgency of the procedure is not understood | Education level varies | Conduct training regularly |
|          |        | Supplier outside | Must be more thorough in the sorting process | |
|          |        | Supplier core | | |
|          |        | Excess TBS at the sorting station | | |
|          |        | Supplier outside | | |

Figure 3. Cause and effect diagrams
From Table 4, it will be explained that improvements will be made from these four aspects. The proposed improvement from the human aspect, the company needs to provide special training for workers who are less skilled, increase the number of workers, or even improve the work environment because it seems that many operators are experiencing fatigue. The proposed improvement from the material aspect is to arrange a schedule for purchasing raw materials to limit the number of suppliers, because this is the main key to the occurrence of accumulation of raw materials and work station imbalance. The proposed improvement from the aspect of working methods is an effort to implement the SOP as a whole, while in the environmental aspect, efforts are made to reduce noise levels or provide ear protection.

4. **Conclusion**

Based on the results of research that has been carried out in the oil palm sorting section, the conclusions obtained are as follows:

- The waste identification process at the oil palm sorting station at PT. Karya Tanah Subur has three non-value added activities, namely moving oil palm fruit to the sorting area, waiting to be unloaded from trucks, loading and unloading and sorting from trucks. In making of the current state map of the oil palm sorting process, the number of non-value added activities was 72%, value added activities was 28%, and the efficiency of the process cycle was 27.3392122%. Then identified in the future state map application by eliminating and minimizing non-value added activities, the number of presenting non-value added activities to 53%, added value activities to 47%, and the proposed process cycle efficiency of 46.909592%.

- Activities in the form of proposed improvements need to be carried out in every existing aspect, such as human, material, method, and environmental aspects.

5. **References**

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