The application of lean manufacturing to minimize waste in Crude Palm Oil (CPO) production process at PT. XYZ

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Abstract. The Crude Palm Oil (CPO) processing industry in Indonesia has grown rapidly. Currently, Indonesia is capable to produce 41.98 million tons of palm oil from 14.03 million hectares land area, with an average selling price for 714.3 US dollars per metric ton. The problems faced by PT. XYZ was CPO production capacity below than the optimal CPO production capacity of 400 tons/day. The problem solving method uses the Lean Manufacturing approach to identify activities that are classified as waste. Based on the results of observations and measurements at PT. XYZ, a non-value added activity of 296.46 minutes with a Process Cycle Efficiency level of 49.01%. The application of improvements using Value Stream Mapping, found that sorting Fresh Fruit Bunch (FFB) at Sorting Station, stacking FFB in Loading Ramp, pouring lorry loads, and flowing CPO into Storage Tank were activities that classified as non-value added activities, which needed to be solved. The results of improvements show an improvement in Manufacturing Lead Time to 489.47 minutes and Process Cycle Efficiency to 58.21%.

1. Introduction
The Crude Palm Oil (CPO) processing industry in Indonesia has grown rapidly. Currently, Indonesia is capable to produce 41.98 million tons of palm oil from 14.03 million hectares land area, with an average selling price for 714.3 US dollars per metric ton. This good business climate contributes to invite the new competitors in the CPO processing industry. In the era of globalization, competition in the industrial world is increasing rapidly. Competitive advantage is shown in the ability of a company to produce the product at the right time, right quality, right amount and with the competitive prices. The only way to raise the company's competitive advantage is depend on the quality of the entire production process. Good quality will only be obtain if the entire production process runs optimally. The optimal states need to minimize or even eliminate all the waste.

PT. XYZ is CPO processing company in North Sumatera, Indonesia. Production capacity of PT. XYZ reaches 400 tons/day, but currently the company is only able to produce CPO of around 300 tons/day. According to researchers' observations, activity that has the biggest waiting or delay time occur in the sorting activity of Fresh Fruit Bunch (FFB). These problems arise due to waste throughout the production process, namely non-value added activity. The aim of the research is to reduce and eliminate waste with Lean Manufacturing approach. According to Gaspersz and Fontana (2011), lean is a continuous improvement effort to eliminate waste in order to increase value added of products, both goods and services to customers.
At least there are two advantages of using Lean Manufacturing compared to other approaches. The first advantage is subtle. It has to do with the starting point of journey into Lean. The second advantage is to achieve large gains in profits, being able to reduce the lead times, becoming more flexible and responsive, and generally becoming a better business.

2. Research Method
The research took place at PT. XYZ, which is located in Blankahan Village, Langkat, North Sumatera, Indonesia. The research was conducted in May 2018 until August 2018. The object of the research was observed all the stages or production process of Crude Palm Oil (CPO). The research takes some steps, starting from identifying problems that occur in the production process. Searching appropriate literature and reference to find out problem solving methods.

Data collected begins by determining the rating factor for each operator of production process, which is carried out directly by observer. The rating factor determination refers to the Westinghouse System Rating, which depend on the skill, effort, condition, and consistency. The allowances is given to personal needs, to eliminating fatigue, and unavoidable obstruction. Standard time calculation using the Stopwach Time Study concept. The Lean Manufacturing approach to identify the entire production process that are classified as waste. Ohno (1955) defined waste in ways that no others had really thought. He described seven types of waste, i.e transportation, waiting, overproduction, defective parts, inventory, movement, and excess processing. The last step is analyzing the results of data processing and providing conclusions and suggestions.

3. Result and Discussion
3.1. Data Uniformity and Adequacy Test
Based on observation, the Crude Palm Oil (CPO) production process flow is shown in the Table 1.

| Process Number | Activity                                   | Cycle Time (minute) |
|----------------|--------------------------------------------|---------------------|
| 1              | Fresh Fruit Bunch (FFB) is weighed on Weighbridge | 0.58                |
| 2              | FFB is delivered to Sorting Station         | 1.14                |
| 3              | FFB is dismantled and sorted                | 27.13               |
| 4              | FFB is poured in Loading Ramp               | 17.93               |
| 5              | FFB is inserted into the lorry              | 12.14               |
| 6              | Lorry is pulled towards the Sterilizer      | 5.99                |
| 7              | Sterilization                              | 95.77               |
| 8              | Lorry pulled out                            | 11.45               |
| 9              | Lorry poured out                           | 37.98               |
| 10             | Fruitlet is separated from empty bunches with Thresher machine | 38.96               |
| 11             | Fruitlet is crushed by Digestor machine     | 11.47               |
| 12             | Palm oil and kernel are produced from the Presser machine | 13.85               |
| 13             | Palm oil’sediment is deposited in the Sand Trap | 35.87               |
| 14             | Palm oil’sediment is filtered with Vibrating Screen | 12.46               |
| 15             | Palm oil is stored in Crude Oil Tank temporarily | 27.99               |
| 16             | Palm oil is separated between oil, water, and sludge with Continuous Storage Tank | 11.40               |
| 17             | Oil and water are deposited in Pure Oil Tank | 34.83               |
| 18             | Oil is put into the Vacuum Dryer machine to separate oil from the water content, so that Crude Palm Oil (CPO) is obtained | 14.09               |
| 19             | CPO is flowed into Storage Tank             | 6.88                |
| 20             | Charging CPO on trucks                      | 27.80               |
The data uniformity test shows that the data is classified as uniform, because all data are spread in the range of Lower Class Boundaries (LCB) and Upper Class Boundaries (UCB). Based on the adequacy of data testing, the number of iterations of data observation (10 times) exceeds the number of minimum data iterations (8 times).

3.2. Standard Time Calculation

Normal time calculation is done by multiplying the average cycle time of each process with a rating factor which aims to adjust the work time among the operators. The standard time represents the time needed by an operator to complete his work by adding the allowance factor at normal time. The calculation of standard time for each process is shown in Table 2.

| Cycle Time (minute) | Rating factor | Normal Time (minute) | Allowance | Standard Time (minute) |
|---------------------|---------------|----------------------|-----------|------------------------|
| 0.58                | 1.18          | 0.68                 | 5.0%      | 0.72                   |
| 1.14                | 1.02          | 1.17                 | 2.0%      | 1.19                   |
| 27.13               | 1.26          | 34.18                | 25.5%     | 45.88                  |
| 17.93               | 1.19          | 21.33                | 23.5%     | 27.89                  |
| 12.14               | 1.19          | 14.44                | 23.5%     | 18.88                  |
| 5.99                | 1.19          | 7.12                 | 23.5%     | 9.31                   |
| 95.77               | 1.00          | 95.77                | 0.0%      | 95.77                  |
| 11.45               | 1.19          | 13.63                | 23.5%     | 17.81                  |
| 37.98               | 1.16          | 44.06                | 37.0%     | 69.93                  |
| 38.96               | 1.08          | 42.08                | 28.5%     | 58.85                  |
| 11.47               | 1.08          | 12.38                | 28.5%     | 17.32                  |
| 13.85               | 1.09          | 15.09                | 28.5%     | 21.11                  |
| 35.87               | 1.00          | 35.87                | 0.0%      | 35.87                  |
| 12.46               | 1.08          | 13.46                | 23.5%     | 17.59                  |
| 27.99               | 1.00          | 27.99                | 0.0%      | 27.99                  |
| 11.40               | 1.08          | 12.31                | 23.5%     | 16.09                  |
| 34.83               | 1.00          | 34.83                | 0.0%      | 34.83                  |
| 14.09               | 1.09          | 15.35                | 23.5%     | 20.07                  |
| 6.88                | 1.00          | 6.88                 | 0.0%      | 6.88                   |
| 27.80               | 1.15          | 31.97                | 14.5%     | 37.40                  |

3.3. Calculation of Manufacturing Lead Time and Process Cycle Efficiency

Manufacturing Lead Time is the time needed to carry out the production process from the beginning to the end based on the standard time. This Manufacturing Lead Time calculation is done by adding up all the work process time which consists of 20 work processes. Process Cycle Efficiency is the measurement that identifies a number of processes that provide value added. The calculation of Process Cycle Efficiency need to classify the activities or production processes, which is belong to value added activity, instead of non-value added activity. The recapitulation of value added time and non-value added time is shown in Table 3.

| Process Number | Activity                                      | Value Added Time (minute) | Non-Value Added Time (minute) |
|----------------|-----------------------------------------------|---------------------------|-------------------------------|
| 1              | Fresh Fruit Bunch (FFB) is weighed on Weighbridge | 0.72                      |                               |
| 2              | FFB is delivered to Sorting Station           | 1.19                      |                               |
| 3              | FFB is dismantled and sorted                  | 45.88                     |                               |
|   | Process Step                              | Time (min) |
|---|-------------------------------------------|------------|
| 4 | FFB is poured in Loading Ramp              | 27.89      |
| 5 | FFB is inserted into the lorry             | 18.88      |
| 6 | Lorry is pulled towards the Sterilizer     | 9.31       |
| 7 | Sterilization                              | 95.77      |
| 8 | Lorry pulled out                           | 17.81      |
| 9 | Lorry poured out                          | 69.93      |
|10 | Fruitlet is separated from empty bunches with Thresher machine | 58.85 |
|11 | Fruitlet is crushed by Digester machine    | 17.32      |
|12 | Palm oil and kernel are produced from the Presser machine | 21.11 |
|13 | Palm oil’sediment is deposited in the Sand Trap | 35.87 |
|14 | Palm oil’sediment is filtered with Vibrating Screen | 17.59 |
|15 | Palm oil is stored in Crude Oil Tank temporarily | 27.99 |
|16 | Palm oil is separated between oil, water, and sludge with Continuous Storage Tank | 16.09 |
|17 | Oil and water are deposited in Pure Oil Tank | 34.83 |
|18 | Oil is put into the Vacuum Dryer machine to separate oil from the water content, so that Crude Palm Oil (CPO) is obtained | 20.07 |
|19 | CPO is flowed into Storage Tank            | 6.88       |
|20 | Charging CPO on trucks                     | 37.40      |

**Total**  
284.92  
296.46

The calculation of Process Cycle Efficiency for the entire production process is shown below.

\[
\text{Process Cycle Efficiency} = \frac{\text{Value Added Time}}{\text{Manufacturing Lead Time}}
\]

\[
= \frac{284.92}{581.38} = 49.01\%
\]

3.4. **Designing SIPOC Diagram**  
The aim of designing SIPOC diagram is to provide information of material’s flow. The elements used in the SIPOC diagram, i.e:

- **Supplier**: PT. XYZ’s Farmers and Local Farmers
- **Input**: Fresh Fruit Bunch (FFB)
- **Process**: Weighing, Sorting, Sterilization, Thresher, Digester, Presser, Clarification, Charging
- **Output**: Crude Palm Oil (CPO)
- **Customer**: Derivative Factory
The SIPOC diagram for the production process of Crude Palm Oil (CPO) is shown at the Figure 1.

3.5. Designing Current Value Stream Map
Current Value Stream Map (CVSM) is an illustration of the actual production process which includes information of material’s flow. The purpose of this mapping is to identify all types of waste that occur throughout the production process and to take corrective steps in an effort to eliminate these wastes, in order to design the Future Value Stream Map (FVSM).

3.6. Identification of Waste
Identification of the causes of waste is conducted using Cause and Effect Diagram. Analysis is carried out on human, material, machine, method and environment factors. This diagram is designed after having discussion and brainstorming session with the Factory Manager, who has competence of the entire production process. Based on his opinion, there are only four of eleven non-value added activity that able to be solved. It because the lack of fund and the procedure of production process.
| Sorting FFB at Sorting Station |
|-----------------------------|
| Method                      |
| Operators are less deft     |
| Operator works slowly       |
| Urgency of the procedure    |
| not understood by the operator |
| Do not apply SOP            |
| There are no sanctions for disobedient SOP |
| Raw materials are supplied from free market |

**Figure 3.** Sorting FFB at Sorting Station’s Cause and Effect Diagram.

| Stacking FFB in Loading Ramp |
|-----------------------------|
| Method                      |
| Machine                     |
| There are only a few Loading Ramp |
| Low capacity                |
| Imbalance production time   |
| Operates in one shift       |
| Unlimited number of suppliers |
| Raw materials are supplied overload |

**Figure 4.** Stacking FFB in Loading Ramp’s Cause and Effect Diagram.

| Pouring Lorry Loads |
|---------------------|
| Environment         |
| Machine             |
| Absence of cooling process after boiling |
| High temperature    |
| Number of lorry loading machines only one |
| Low capacity        |
| Three lane sterilizers |
| Imbalance production time |
| Pouring method unefficiency |
| Operator works continuously |
| Operator exhausted |

**Figure 5.** Pouring Lorry Loads’ Cause and Effect Diagram.

| Flowing CPO into Storage Tank |
|-------------------------------|
| Machine                       |
| CPO filling rate low          |
| Number of CPO filling points only two |
| Charging Station far away     |
| Flow rate low                 |
| The pump is not on the ideal conditions |
| Operator works continuously   |
| Operator exhausted            |

**Figure 6.** CPO Flowing into Storage Tanks’ Cause and Effect Diagram.
3.7. Calculation of Manufacturing Lead Time’s Improvement and Process Cycle Efficiency’s Improvement

After take improvement actions, there will be recalculation of Manufacturing Lead Time. The Calculation of Manufacturing Lead Time’s Improvement is shown in the Table 4.

Table 4. Value Added Time and Non-Value Added Time’s Improvement.

| Process Number | Activity                                           | Value Added Time (minute) | Non-Value Added Time (minute) |
|----------------|----------------------------------------------------|----------------------------|-------------------------------|
| 1              | Fresh Fruit Bunch (FFB) is weighed on Weighbridge   | 0.72                       |                               |
| 2              | FFB is delivered to Sorting Station                | 1.19                       |                               |
| 3              | FFB is dismantled                                 | 25.62                      |                               |
| 4              | FFB is poured in Loading Ramp                      | 10.89                      |                               |
| 5              | FFB is inserted into the lorry                     | 18.88                      |                               |
| 6              | Lorry is pulled towards the Sterilizer             | 9.31                       |                               |
| 7              | Sterilization                                     | 95.77                      |                               |
| 8              | Lorry pulled out                                   | 17.81                      |                               |
| 9              | Lorry poured out                                   | 20.28                      |                               |
| 10             | Fruitlet is separated from empty bunches with Thresher machine | 58.85                     |                               |
| 11             | Fruitlet is crushed by Digester machine            | 17.32                      |                               |
| 12             | Palm oil and kernel are produced from the Presser machine | 21.11                     |                               |
| 13             | Palm oil’sediment is deposited in the Sand Trap    | 35.87                      |                               |
| 14             | Palm oil’sediment is filtered with Vibrating Screen | 17.59                     |                               |
| 15             | Palm oil is stored in Crude Oil Tank temporarily   | 27.99                      |                               |
| 16             | Palm oil is separated between oil, water, and sludge with Continuous Storage Tank | 16.09                     |                               |
| 17             | Oil and water are deposited in Pure Oil Tank       | 34.83                      |                               |
| 18             | Oil is put into the Vacuum Dryer machine to separate oil from the water content, so that Crude Palm Oil (CPO) is obtained | 20.07                     |                               |
| 19             | CPO is flowed into Storage Tank                    | 1.88                       |                               |
| 20             | Charging CPO on trucks                             | 37.40                      |                               |
| Total          |                                                    | 284.92                     | 204.55                       |

The calculation of Process Cycle Efficiency for the entire production process shown at below.

\[
\text{Process Cycle Efficiency} = \frac{\text{Value Added Time}}{\text{Manufacturing Lead Time}} = \frac{284.92}{489.47} = 58.21\%
\]
3.8. Designing Future Value Stream Map

Future Value Stream Map (FVSM) is a description of the proposed production process which includes information of material’s flow. The purpose of this mapping is to compare Future Value Stream Map (CVSM) to Current Value Stream Map (CVSM), after taking improvement efforts to minimize the waste.

![Figure 7. Future Value Stream Map.](image)

4. Conclusions

Based on the research and problem solving analysis, the conclusions obtained are as follows.

1. The production process at PT. XYZ has eleven activities that do not provide value added or been categorized as non-value added activity. Based on the Factory Manager’s opinion, there are four of eleven non-value added activity, that able to be solved. They are sorting FFB at Sorting Station, stacking FFB in Loading Ramp, pouring lorry loads, and flowing CPO into Storage Tank.
2. The current state shown that Manufacturing Lead Time is 581.38 minutes decreased by 91.91 minutes to 489.47 minutes, after improvements, the actual of Process Cycle Efficiency is 49.01%, increased by 9.2% to 58.21%.

Reference

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