Production process analysis using value stream mapping at East Java sugarcane industry

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Abstract. The purpose of this research is to identify the type of waste and to propose improvements for waste minimization on the processing process at the sugarcane industry. This research uses Value Stream Mapping and Value Stream Analysis Tools (VALSAT) method. The results showed that the highest waste in the process production consisted of waiting time and inappropriate processing. Recommendations for improvements that given include reduction of time at several stages of the process, and perform periodic maintenance of the machine. Process Activity Mapping analysis shows reduced lead time from 1212.07 minutes to 1176.23 minutes.

1. Introduction
The need for sugar consumption continues to increase every year. This is in line with the increase in population and the growth of the pharmaceutical industry as well as food and beverages[1]. At present, domestic sugar production has not been able to meet consumption needs, because domestic production tends to decrease [2]. The development of the sugar industry must be carried out in an integrated manner starting from plantations, processing, marketing and distribution supported by stakeholders including supporting institutions such as R&D, HR, finance/banking and transportation [3].

The processing stage in sugar mills still has latent problems that make the sugar industry less in performance, namely the inefficiencies that occur in almost every workstations from milling, refining, evaporation, cooking, screening to packaging stations [4]. XY Sugar Factory is one of the sugar cane industries with sugar production of 468,337 tons in the 2014 milling season and in 2015 the productivity decreased to 430,539 tons. In identifying and reducing waste that can cause a decrease in productivity in the XY sugar mill, a comprehensive analysis is needed.

The main problem faced by manufacturers is how to deliver their products quickly at low cost and good quality [5]. Several approaches exist such as supply chain, statistical analysis and computer simulation [6]. One of the most successful approaches in increasing efficiency is Lean Manufacturing (LM). This research uses the concept of LM, using a systematic approach to identify and minimize
waste through continuous and sustainable improvement and development, trying to make the production flow smoothly to try to attract consumers’ attention in an effort to achieve perfection [7]. The LM approach is carried out using the Value Stream Mapping (VSM) method [8]. VSM is used to find waste in describing the value stream where if the waste has been found then the waste must be eliminated [9]. The method that can be done to identify waste is Value Stream Analysis Tools (VALSAT). VALSAT is used to analyze the most common waste and provide recommendations for improvement [10].

2. Materials and methods
This research was carried out at the XY Sugar Factory with the methods used in this study were VSM and VALSAT. VSM covers all processes of added value and non-value added value, starting with raw materials, and ending with customers [11]. The first step taken in this research is to determine the standard time in production process. The second step is construct the current state mapping. To construct the current state map, observation is needed on the production line [12]. Data collection took place from June to August 2017 at XY Sugar Factory facility in East Java Indonesia. The data collected include production lead times, defective products, material flow, factory layout, operator activities, inventory. The third step is to identify waste. Waste is regarded as non-value adding operations such as overproduction, waiting, transportation, inappropriate processing, unnecessary inventory, unnecessary motion, defect, power and energy, human and potential, environmental pollution, unnecessary overhead and inappropriate design [13]. The fourth step is to arrange the process activity mapping. Every activity is breakdown as detailed as possible, this stage is used to identify non-value added activities. Finally, the determination of the future state mapping, this stage is eliminating non value added activity in the production process.

3. Results and Discussion
3.1. Determination of the current state mapping
The determination of the current state mapping is done by mapping the material flow and information related to the material flow itself to provide an actual description of the production process and identify wastes that occur in the material flow of the production floor [13]. This grouping is carried out in each production process of the White Crystal Sugar. Activities that are classified as Value Added (VA), Non Value Added (NVA) and Necessary but Non Value Added (NNVA), which can be seen in Figure 1.

Based on the total amount of time obtained, it was found that some activities classified as VA were 658.92 minutes or 54%, NVA amounted to 465.84 minutes or 39% and NNVA was 87.31 minutes or 7%. Based on the amount of time obtained based on each activity, the total overall time needed during the production is 1212.07 minutes.

3.2. Waste identification
The next step is to identify the most dominant waste that occurs in the process of producing the sugar cane. The weighting of 12 types of waste is done by brainstorming with the production part of the company, using the questionnaire method. The complete questionnaire recapitulation results of waste identification can be seen in Table 1. The results from Table 1 will be used to analyze and identify the wastes that occur. The selection of tools in the VALSAT is based on the correlation value between
each tool and the most common waste [14]. The analytical tools obtained from the VALSAT
calculation results in this study are Process Activity Mapping.

Figure 1. VA, NVA and NNVA Activity

| Waste Identification     | Score | Ranking |
|--------------------------|-------|---------|
| Overproduction           | 0.6   | 4       |
| Waiting                  | 2     | 1       |
| Transportation           | 0     | 7       |
| Inappropriate Processing | 1.4   | 2       |
| Unnecessary Inventory    | 1.2   | 3       |
| Unnecessary Motion       | 0.4   | 5       |
| Defect                   | 0.4   | 5       |
| Power and Energy         | 0.6   | 4       |
| Human and Potential      | 0.4   | 5       |
| Environmental pollution  | 0.6   | 4       |
| Unnecessary overhead     | 0.6   | 4       |
| Inappropriate design     | 0.2   | 6       |

3.3. Process activity mapping

The data needed in determining the Process Activity Mapping (PAM) is the time of each process. The
initial stage of PAM formation is to breakdown each activity as detailed as possible, then consider the
allowance of each activity so that the standard time is obtained [14]. The results of PAM obtained that
the sugar production process at PG XY for 1212.07 minutes. Based on the PAM, the activities that can
be included as operations are up to 15 activities, transportation are up to 13 activities, inspection are
up to 6 activities, delay are up to 3 activities and the storage are up to 2 activities. By using this
analysis tool, the time on transportation activities, inspection and delay can be minimized [15].

The complete results of PAM can be seen in Table 2. From the process of waste identification in
the production process of sugar cane at the XY sugar factory, it has been obtained that the most
common non value added is in waiting and inappropriate processing. The main cause of this type of
waste occurs because the machine weighing sugarcane raw materials at the weighing station is only
one with a limited number of operators. Besides that, the frequent downtime at the grinding station also causes waiting on the work in process. The improvement recommendations for the waste include:

1. The factory considers the addition of weighing machines and an increase in the number of workers in charge of linking pulleys with sugar cane raw materials in the truck. The addition of weighing machines is still very possible because the area of the weighing station is quite wide.

2. Recommendations to overcome the cane cutter and unigrator machine damage that often occur at the milling station would be to make sure that the operator at the milling station pay attention to the volume flow of the sugarcane raw material used so that no obstacles occur during the production process. Maintenance training is needed for operators at each station, so that when the engine has problems it can be handled directly (autonomous maintenance).

3. Application of preventive maintenance to factory machines, and scheduling of spare parts changes, especially at milling stations.

4. Reduce some activities that are considered unnecessary, so that the production process can run more efficiently.

### Table 2. Process activity mapping of white crystal sugar production.

| No | Step                                                                 | Flow | Machine                  | Distance (m) | Minute |
|----|----------------------------------------------------------------------|------|--------------------------|--------------|--------|
| 1  | Cane truck enter the milling station area                            | I    | Crane Scale              | 0            | NVA    |
| 2  | Cane truck queue                                                    | D    | Crane Scale              | 30           | 18.12  |
| 3  | Cane raw materials examination (BBT)                                 | T    | Crane Scale              | 10           | 12.43  |
| 4  | Cane scale pulley hook installation                                  | 0    | Crane Scale              | 0            | 18.06  |
| 5  | Cane raw materials scaling                                          | 0    | Crane Scale              | 5.18         | VA     |
| 6  | Cane raw materials movement from trucks to lorries                  | T    | Transloading Crane       | 11.12        | NVA    |
| 7  | Waiting for the lorry to saturate sugar cane raw materials          | D    | Lorry                    | 5            | 13.43  |
| 8  | Cane raw materials movement to the storage area                     | T    | Lorry Train              | 50           | 7.17   |
| 9  | Milling queue of cane raw material in the lorry                    | S    | Lorry                    | 30           | 25.35  |
| 10 | Cane raw materials movement from the storage area to the milling station | T    | Lorry Train              | 23           | 4.45   |
| 11 | Cane raw materials movement from the lorry to the sugar cane table | T    | Transloading Crane       | 12.07        | NVA    |
| 12 | Cane arrangement at the sugar cane table                            | 0    | Crane Cutter and Unigrator | 5           | 23.48  |
| 13 | Cane draining to be chopped and beaten                               | T    | Crane Table              | 8            | 10.35  |
| 14 | Cane draining to the miller                                         | T    | Rake Elevator            | 12           | 10.35  |
| 15 | Cane milling and imbibition water addition                          | 0    | 4 Throw Mills            | 8            | 10.35  |
| 16 | Raw juice filtering                                                  | 0    | Rotary Vacuum Filler     | 2            | 10.35  |
| 17 | Raw juice pumping                                                    | T    | Compressor               | 3            | 5      |
| 18 | Raw juice scaling and phosphoric acid addition                       | 0    | Mixed Juice Tank         | 4            | 5      |
| 19 | First warming                                                       | 0    | Juice Healer 1           | 2            | 30     |
| 20 | Lime milk addition (defecation process)                             | 0    | Reactor                  | 3            | 3      |
| 21 | SO2 gas addition (sulfitation process)                              | 0    | Sulphitor Juice          | 3            | 3      |
| 22 | Second warming                                                      | 0    | Juice Heater 2           | 3            | 30     |
| 23 | Deposition                                                           | 0    | Flash Tank               | 4            | 30     |
| 24 | Flocculants addition                                                | 0    | Snowballing              | 4            | 5      |
| 25 | Filtering liquid juice                                              | 0    | Dorr Clarifier           | 4            | 5      |
| 26 | Liquid juice shelter                                                | S    | Clean Juice Tank         | 4            | 30     |
| 27 | Used steam pumping and first evaporation                             | 0    | Vacuum Evaporator 1      | 30           | VA     |
| 28 | Juice steam pumping and second evaporation                           | 0    | Vacuum Evaporator 2      | 30           | VA     |
| 29 | Juice steam pumping and third evaporation                            | T    | Vacuum Evaporator 3      | 30           | VA     |
The improvement recommendations used as a reference are the process activity mapping tool. In the current state map it is known that the total production lead time is 1212.07 minutes. The improvement recommendations that can be made are a reduction in the time of several processes such as waiting/delay time, transportation and inspection [16]. After the improvement, the total time is reduced to 1176.23 minutes which means there is a time reduction of 35.84 minutes. The results of the minimization of time Future State Mapping in production process of White Crystal Sugar in XY Sugar Factory can be seen in Table 3.

Table 3 Time minimization in the future state mapping of the white crystal sugar production process in XY Sugar Factory.

| No | Process Stages                                      | Current Mapping (Minutes) | Future Mapping (Minutes) | Time Minimization (Minutes) |
|----|-----------------------------------------------------|---------------------------|--------------------------|-----------------------------|
| 1  | Sugarcane truck queue                              | 18.12                     | 12.36                    | 5.76                        |
| 2  | Inspection of raw sugarcane                        | 12.43                     | 9.53                     | 2.9                         |
| 3  | Installation of crane scale pulley                  | 18.06                     | 12.36                    | 5.7                         |
| 4  | Transfer of raw sugarcane in the lorry to the storage area | 7.17                     | 5.18                     | 1.99                        |
| 5  | Transfer of raw sugarcane from the storage to the milling station | 4.45                     | 3.18                     | 1.27                        |
| 6  | Product transfer from the factory to the warehouse A | 37.25                     | 23.14                    | 14.11                       |
| 7  | Product arrangement in the warehouse                | 15.42                     | 11.31                    | 4.11                        |
|    | Total                                               |                           |                          | 35.84                       |

5. Conclusion
The most dominant type of waste that occurred in the production process of White Crystal Sugar in XY Sugar Factory was waiting/delay and inappropriate processing. The recommendations for improvements provided are considering the addition of weighing machines, the implementation of preventive and corrective maintenance and the efficiency of non-value added activities. Based on the current state mapping, the production time is 1212.07 minutes. After efficiency in several activities,
there was a minimization of time of 35.84 minutes so that the total production time was 1176.23 minutes.

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