

Lean Manufacturing: Waste Reduction Using Value Stream Mapping

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Abstract. Cristal Sri Sujarwati is a small medium enterprise (SME) that produce keripik salak in Sleman, Yogyakarta. To survive and win industrial competition, Cristal Sri Sujarwati was required to improve its performance. But in reality there was a lot of waste in order fulfillment processes marked by ineffective and inefficient work. In this research, lean manufacturing aims to identify and eliminate waste so that the company could improve its performance in winning the industry competition. Lean manufacturing is a systematic approach used to identify and eliminate waste. This lean concept could improve responsiveness through waste reduction, continuous improvement and cost reduction. In order to identify and eliminating waste, a value stream mapping tools, waste weighting questionnaire, value stream analysis tools, and fishbone diagram are used. From the results of research, the dominant waste in the production process was waste defects, waiting, and unnecessary inventory. To eliminate waste, process activity mapping (PAM), the one of detailed mapping tools in VALSAT are used. From the results of the improvement recommendations analysis, lead time decreased by 80 minutes. From the analysis using PAM, there was a reduction of NVA activity from 3.10% to 1.01%.

Keywords: Lean Manufacturing; Process Activity Mapping; Value Stream Mapping; VALSAT; Waste.

1 Introduction

Efficiency and competitiveness of a company are the two most important challenges in the global market. This makes many manufacturing companies are competing to update its manufacturing strategy management. The problems most commonly faced manufacturing companies today is how to deliver a product or material with fast, cheap, and with good quality. Some methods or approaches such as computer simulation, statistical analysis, and lean tools are used to improve efficiency and productivity by determining the best combination on the production line process of construction, energy, services and supply chain. Increased efficiency and productivity is done so that the company can survive and win industry competition [1].

Cristal Sri Sujarwati is one of a Small and Medium Enterprise (SME), that produces a variety of food from salak in Sleman, Yogyakarta. In orders fulfillment, companies often have difficulty because there is waste in the production process that are not identified. Waste is defined as all activities that consume time, space and resources but does not contribute to satisfying the needs of consumers [1]. Identification of waste needs to be

done in order to know what waste it is in the production process, and to do improvements.

In that case, as an effort to solve the problem, lean manufacturing concept is applied. This concept is one approach that is widely used by manufacturing companies to be able to win the competition and meet the high demands of consumers. This concept is used to improve business responsiveness through waste reduction, continuous improvement and cost reduction [1]. The aims of this study is to identify what kind of waste in the order fulfillment; determine the precise detailed mapping tools to reduce waste; propose the root cause of waste and improvement planning; determine the comparison of lead time before and after the production process improvement.

2 Literature Review

2.1 Lean Manufacturing

Lean is a continuous improvement to eliminate waste and increase the value-added (VA) products both goods and services to provide value to customers [2]. Lean

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manufacturing can be defined as a systematic approach to identify and eliminate waste or non-value added (NVA) through continuous improvement by delivering products (materials, WIP and output) and information using pull or pull systems [3].

In lean manufacturing approach, there are three activities that must be differentiated, namely:

- a. Activities that do not provide added value (non value added) and can reduced or eliminated.
- b. Activities that do not add value but can not be eliminated, or necessary (necessary non value added).
- c. Activities that provide added value (value added).

2.2 Waste

The main principle of the lean concept is to reduce or eliminate waste. Waste is an activity that does not provide value added (value added) in the process along the value stream [4]. According to Toyota's Production System (TPS), there are seven things categorized as waste [5], i.e:

- a. Overproduction, producing more than needed and excess stock is overproduction waste [5].
- b. Defect, rejected/ defective finished products can disrupt production and require expensive rework.
- c. Waiting or idle time includes waste. This is because it does not add value to the product.
- d. Transportation, includes the transfer of goods/ materials are too frequent and delay the movement of material. The main cause of excess transport is the plant layout [2].
- e. Inappropriate Processing, includes unnecessary processes or procedures, goods production but does not add value to the product itself.
- f. Unnecessary Motion, poor organizing work stations, resulting in poor ergonomics. The motion of someone who is not directly related to the added value is unproductive.
- g. Unnecessary Inventory, finished products, semi-finished goods, or components with inventory status do not add value.

2.3 Value Stream Mapping (VSM)

Value Stream Mapping (VSM) is a visual method for mapping the production line of a product that includes material and information from each work station. Using VSM means getting started with a big picture in solving problems not just on single processes and improving thoroughly and not just on certain processes [3].

According to [6], VSM consists of two types that can help to make real improvements, namely:

- a. Current State Map (CSM), is the current product value stream configuration, uses specific icons and terminologies to identify wastes and areas for improvement.
- b. Future State Map (FSM) is a blueprint for the desired lean transformation in the future after the waste identification and elimination.

2.4 Value Stream Analysis Tools (VALSAT)

Value stream analysis tools (VALSAT) are used to analyze the identified waste. The VALSAT concept is used in the selection of detailed mapping tools by multiplying the waste weights from WAQ (Waste Assessment Questionnaire) with the scale shown in the VALSAT table [8].

The following are the most commonly used detailed mapping tools for waste analysis:

- a. Process Activity Mapping (PAM) is a tool for mapping the production process in detail that is used to determine the proportion of activities grouped in value added (VA), necessary non-value added (NNVA), and non-value added (NVA).
- b. Supply Chain Response Matrix (SCRM), is a graph that connects between cumulative inventory with cumulative lead time on the distribution channel used to determine the increase or decrease inventory levels and lead time lengths at the time of distribution of each supply chain area [9].
- c. Production Variety Funnel (PVF), is a visual mapping technique where in a sequence of processes there is an increase in product variation.
- d. Quality Filter Mapping (QFM), is a tool used to map where quality problems arise in an existing supply chain [10].
- e. Demand Amplification Mapping (DAM), a tool used to map patterns or demand changes in each supply chain [10].
- f. *Decision Point Analysis* (DPA) is the point where there is a change in the trigger of production activities that initially based on the forecast to be based on orders [10].
- g. Physical Structure (PS), is a tool that used to understand the condition of the supply chain on the production floor [5].

2.5 Fishbone Diagram

Fishbone diagrams are used to identify and show possible causes of problems and especially when a team tends to fall into thinking on a routine [7]. Figure 1 below is a picture of fishbone diagram with 5M and 1E factors that are often used:

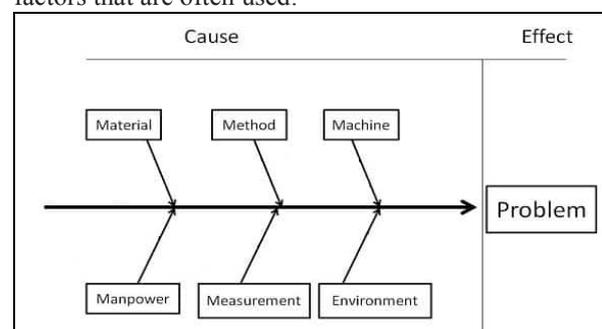


Fig. 1. Fishbone Diagram [11]

3 Methodology

In this study the research methodology conducted by stages as follows:

Stage of data collection and processing is done by interview, observation with a direct view on the field and questionnaires. Data collected include: 1. Information products; 2. Data flow information and material; 3. Details of the production process; 4. The cycle time; 5. Identify waste. Stages of data processing are divided into several steps, among others:

3.1 Value Stream Mapping (Current State)

Current state mapping used to determine the initial conditions of the production processes prior to repair, and used to identify other types of waste, which is used as a reference for improvement.

3.2 Waste Identification - Weighting Questionnaire

At this stage the author makes a waste-weighting questionnaire, which is used to identify the most dominant waste in the system. Weighting is done by assigning value to each waste, using Likert scale according to the frequency level that occurs during the production process.

3.3 Value Stream Analysis Tools (VALSAT)

VALSAT (Value Stream Analysis Tools) helps in determining the detailed mapping tools that will be used to reduce the dominant waste during the production process. With the percentage of the most dominant waste weight as VALSAT input, the stages are:

- Changing the scale of linguistic H, M and L on VALSAT into a numerical scale on the columns value stream map.
- Input the weight of each type of waste based on the waste identification output on the VALSAT.
- Multiply the weight of waste at waste weighting with a numerical scale for each column value stream mapping tools with numeric scale multiplier.
- Summary the result of the multiplication of each column value stream mapping to determine what the greatest.
- Select the greatest value for the detailed mapping using the right tools.
- Waste identification using selected tools for the analysis and conclusion.

3.4 Fishbone Diagram

Fishbone diagrams can identify and show possible causes of problems, especially when a team tends to fall into thinking on a routine. The stages are as follows:

- Selecting or collecting potential waste problems experienced.
- Identifying the cause categories.
- Finding the cause of a potential by way of brainstorming.
- Review and agree on the causes most likely.

3.5 Improvements Recommendation

Provide recommendations for improvement to eliminate the most dominant waste. Recommendations for improvements should be implemented in actual conditions and should also be effective in eliminating the dominant waste

3.6 Comparison of Actual Condition and Recommendations Condition

This phase is intended to determine the extent of repairs carried out successfully. Comparisons the lead time before and after improvements intended to see the potential of the company if the waste is eliminated. The stages are:

- Calculating lead time of the actual conditions by using cycle time before the repair.
- Calculating the cycle time and lead time after repairs on the future state map by eliminating non-value adding.
- Doing a comparison of cycle time and lead time before and after repair.

4 Result And Discussion

4.1 Current State Mapping

Current state mapping (CSM) is a description of the operating conditions that occur in the production process at this time. CSM describe the production process from beginning to end, so the issues that involved can be know, and do analyze their waste in the process. Figure 2 shows the current state map of keripik salak.

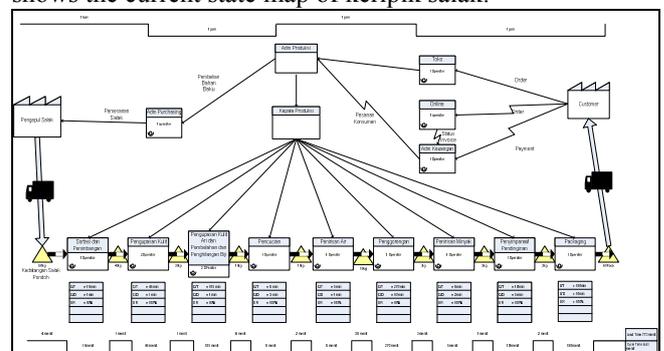


Fig. 2. Current State Mapping

4.2 Waste Identification

Waste identification is done by distributing questionnaires to the employees who understand the impact and keripik salak production process regarding the level of frequency of waste that occurred. The waste weighting results can be seen in Figure 2.

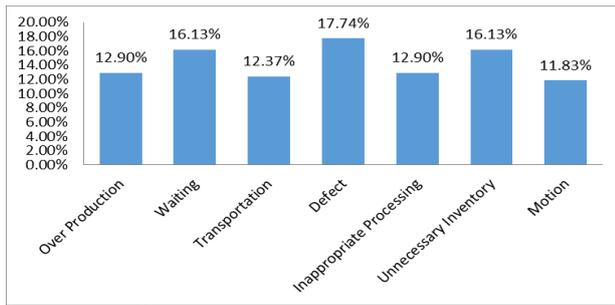


Fig. 3. Percentage of Waste Weight

4.3 Value Stream Analysis Tools (VALSAT)

After obtained a score of each waste, then converted into a matrix VALSAT to get the detailed mapping tools that will be used. Furthermore, the results VALSAT conversion matrix can be seen in Figure 4.

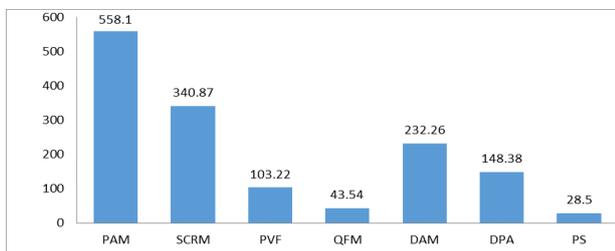


Fig. 4. Detailed Mapping Tools Score

4.4 Process Activity Mapping (PAM)

Process Activity Mapping (PAM), is a tool used to map the detail of production process and then used to determine the proportion of activities grouped in value added (VA), Necessary non value added (NNVA), and non-value added (NVA). By grouping their production line activities, PAM is used to identify the waste that occurs in every process. In this tools, the existing activity at each work station are grouped into five types of activity, namely O (Operation), T (Transportation), I (Inspection), S (Storage), D (Delay).

Based on PAM production process of keripik salak, Table 2 below is the recapitulation time and percentage of each activity category:

Table 2. Recapitulation of Process Activity Mapping

Activities	Total	Time	Percentage
Operation	12	624	80,72%
Transportation	14	49	6.34%
Inspection	1	12	1,55%
Storage	1	10	1.29%
Delay	12	78	10.09%
Total	40	773	100%
Classification	Total	Time	Percentage
VA	13	641	82.92%

NNVA	14	108	14.62%
NVA	13	24	2.46%
Total	40	773	100.00%

4.5 Fishbone Diagram

According to the waste identification in the previous section, the most dominant waste in this company is defect, waiting and unnecessary waste inventory. The causes of each waste can be seen in the next section, namely Improvement Recommendation.

4.6 Improvement Recommendation

The following recommendations for improvements are made by identifying the causes of waste using fishbone diagrams and eliminating NVA activities based on established PAMs. Recommendations for improvements made to eliminate the dominant waste and NVA activities in order fulfillment processes. Here are recommendations for proposed improvements:

4.6.1 Eliminating Waste

Based on the problems described in the previous section, the elimination of waste from waste identification can be seen in Table 3 below:

Table 3. Improvement Recommendation

Sub Waste	Causes	Secondary Causes	Recommendations for Improvements
Defect	Raw materials not suitable	Passed sorting	Reselection of suppliers and tightening up on sorting raw materials
	Final product passes inspection	limitations visual	Tightening final product inspection and making quality control card
	Power outages from center	No notification	Request notification blackout or buy diesel
Waiting	The production process depend on the arrival of raw materials	-	-
	Available supplier	-	Selection of suppliers
	The raw materials can not be predicted	From nature and seasonality	-
Unnecessary Inventory	System order to stock	Resource utilization	Making another type product
	Lack of machine	-	Making a job descriptions and SOP for each work stations and

Sub Waste	Causes	Secondary Causes	Recommendations for Improvements
			operators
	The raw material is not within specifications	Order to stock	Making another type product

4.6.2 Eliminating NVA Activities

This stage is done by eliminating activities that are categorized as non value adding, so that production time can be reduced. In addition, efforts to shorten production lead time is also done by changing the sequence of activities that are not efisien and increase the number of operators in activities which require more work load.

4.6.3 Future State Mapping

FSM (Future state mapping) conditions are ideal targets to be achieved. According to the improvement recommendations in the previous section, the following is a comparison of cycle time between the current state and the future state by eliminating the NVA activity.

Tabel 4. Comparison of Total Cycle Time

Process	Average Cycle Time	
	CSM	FSM
Sorting, weighing and entry	20	18
Stripping the bark	48	30
Peeling of Ari Skin and Cleavage	107	70
Washing	14	10
Water seeping	8	5
Frying	358	343
Oil seeping	10	10
Storage	16	16
Packaging	192	191

Based on the average cycle time in the Tabel 4, then created the future state map in figure 8:

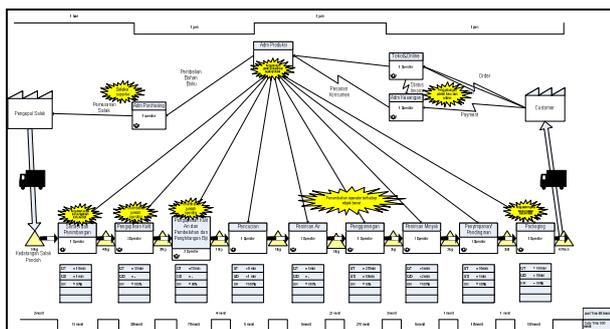


Fig. 5. Future State Mapping

4.7 Comparison of Actual Condition and Conditions Recommendations

According to the elimination of waste and NVA activities using PAM, obtained comparison a lead time between actual conditions (CSM) and the recommendation condition (FSM). Figure 9 shows a comparison of lead time on the CSM and FSM:

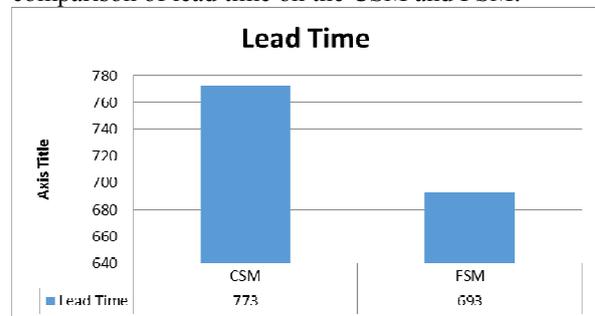


Fig. 6. Comparison of Current State Mapping and Future State Mapping

5 Conclusion

Based on the result, dominant waste in the keripik salaks production process is defect, waiting and unnecessary inventory. PAM is the chosen VALSAT mapping tools with total score 558.1 and there is a VA activities amounted to 82.92%, NNVA amounted to 14.62%, and the NVA amounted to 2.46%. The improvement recommendations can be seen in Tabel 3. In future state mapping, the lead time was reduced from 773 minutes to NVA 3.10% to 693 minutes with NVA 1.01%. This research has contribution to develop low carbon society. Waste reduction, especially overproduction and transportation give direct impact to reduce carbon emissions. Further research, a study about waste reduction can be done with lean and green supply chain approaches.

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