Minimize waste on production process using lean concept

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Abstract. This research aims to analyze and minimize the waste that occurs in the production process by using a lean production approach. One of the factors that can influence ineffective and inefficient in the production process is waste in the production process. An effective and efficient production process will support the company to increase productivity. The problems that occur in company X are companies that still often experience delays in meeting consumer demand, and there are still defect products. These problems have to be solved. One approach is to incorporate lean principles in the production process. From the results of the analysis, activity mapping obtained the value-added activity (VA) has the lowest percentage of 13.60% and non-value-added activities (NVA) has a percentage of 59.80%, which cause of delay. Solution to minimize waste are improve inspection process, scheduling maintenance, make standard operation procedure and reduce set up time.

1. Introduction
In the globalization, companies are required to minimize waste, even to zero waste. Generally, waste is generated from operational activities. Waste comprises seven types, including overproduction, waiting, movement transportation, unnecessary processes, inventory, and defects [1]. These need to be reduced in order for the company to be competitive. One solution to waste management is lean production [1]. Lean production is a systemic and systematic approach to the elimination of waste and non-value-added activities [2, 3]. As a consequence, Lean Manufacturing has attracted the interest of scholars. At present, several research reports have shown the performance of businesses in developed countries (e.g., United States, China, Germany, United Kingdom, and Italy) by implementing the Lean Manufacturing concept [3].

Many prior researchs has been done on lean production. Valsat is the most common waste reduction tool [4]. In addition, several solutions to waste weighting included the Borda [5] and the Waste Assessment Model [6]. Furthermore, several tools for solving lean manufacturing problems included Process mapping [7], Kaizen/Continuous improvement [8], Just in time [9], Poka-yoke [10], Failure Mode And Effect Analysis (FMEA) [11] and Kanban [12]. Moreover, methods are used in part based on previous research. In this study, we suggested a strategy by combining the approaches of Borda, Valsat, and FMEA. No previous studies have been conducted using a combined approach of the Borda, Valsat, and FMEA methods.

The goal of this article is to develop a method of waste reduction by integrating the Borda, Valsat, and FMEA systems. The Borda method was chosen because it is easy to use in weighting. In addition, this produced accurate weights in identifying waste. Valsat was chosen as a mapping tool for lean manufacturing. Furthermore, FMEA was used to identify the cause of waste. The main contribution
proposed in this field is to propose new concepts with a combination of Borda, Valsat, and FMEA methods to reduce waste.

2. Methods

This research done with five steps (Figure 1). First step is make a map of production process. This map shows current production process. The method for mapping the production process using value stream mapping tools. Second step is measure waste on production process using borda method. Third step is determining value stream mapping tools (VALSAT). VALSAT is a tools to determine the value stream in details which focused on the value adding process. The detail mapping then can be used to identify the causes of wastes [13]. There are seven types of detail mapping tools that most commonly used consist of process activity mapping, supply chain response matrix, production variety funnel, quality filter mapping, demand amplification mapping, decision point analysis, and physical structure [4]. A detail mapping tools with the highest value is selected to analyze the wastes in the cigarettes production process. FMEA is applied to determine the failure modes of wastes in the cigarettes production process. Failure modes are the error conditions which affecting waste in the system. In this stage, each of the failure modes is assessed in terms of severity, occurrence, and detection with with a scale ranging from 1 to 10 adopted from [11, 14]. The risk priority number (RPN) is then calculated and ranked to obtain the wastes with the highest failure modes. Finally, the action plans are developed to eliminate the wastes and improve the efficiency of the cigarettes production process.

![Figure 1. Research methodology](image)

3. Result and Discussion

This study is conducted in a cigarettes manufacturing company located in East Java, Indonesia. The production flow is shown in current value stream map presented in Fig. 1. The waste assessment is done by weighting the results of the questionnaire using the Borda Count Method (BCM). Respondent ranks each waste according to the level of frequency and its effect on the production process of cigarettes, which ranks 1 through 7. For waste that has a rating of 1 is the waste often occurs and is very influential in the cigarette production process. By the following Table 1 are the result of the Borda method.

| Table 1. Result the borda method |
|----------------------------------|
| **Final** | **Score** | **Normalization** | **Rank** |
| Overproduction | 0 0 0 4 4 4 | 0,040 | 7 |
| Defects | 8 0 0 0 32 | 0,323 | 1 |
| Unnecessary Inventory | 0 0 1 2 4 | 0,040 | 6 |
| Unappropriated processing | 6 2 0 0 30 | 0,303 | 2 |
| Excessive Transportation | 0 0 0 5 5 | 0,051 | 5 |
| Waiting | 2 2 0 4 18 | 0,182 | 3 |
| Unnecessary Motion | 0 0 2 2 4 | 0,061 | 4 |
| Weight | 4 | 3 | 2 | 1 | 0 | 99 |
|--------|---|---|---|---|---|----|
Figure 2. Current state map

The Value Stream Analysis Tools (VALSAT) is used to choose a detail mapping tools. The tools will be applied to analyze the wastes in the cigarettes production process. The value of each of the mapping tools is calculated by multiplying the weight of waste resulted from borda method with the scale of VALSAT. The correlation value of VALSAT has three scales consist of high (9), medium (3), and low (1). The results are shown in table 2.

Table 2. VALSAT

| Waste                      | PAM  | SCRM | PVF  | QFM  | DAM  | DPA  | PS  |
|----------------------------|------|------|------|------|------|------|-----|
| Overproduction             | 0.040| 0.121| 0.040| 0.121| 0.121| 0.121|     |
| Defects                    | 0.323| 2.909|      |      |      |      |     |
| Unnecessary Inventories    | 0.121| 0.364| 0.121| 0.364| 0.121| 0.040|     |
| Inappropriate Processing   | 2.727| 0.909| 0.3033| 0.3033|      |      |     |
| Excessive Transportation   | 0.455|      |      |      | 0.051|      |     |
| Waiting                    | 1.636| 1.636| 0.182| 0.545| 0.545|      |     |
| Unnecessary Motion         | 0.545| 0.061|      |      |      |      |     |
| Total                      | 5.848| 2.182| 1.212| 3.253| 1.030| 1.091| 0.091|

The results show the Process Activity Mapping (PAM) identified as the highest value of mapping tools with a score of 5.848. Therefore, PAM is then applied to analyze the cigarettes production process. The PAM uses the symbols that represent the activities such as operations, transportation, inspection, delay, and storage. PAM is a technical approach that usually used in activities on the production floor. Besides, this tool can be used to identify the lead time and productivity of the physical products flow and the information flow, not only within the company but also within the supply chain area. The basic concept of this tool is to map every stage of activity that occurs from operations, transportation, inspection, delay, and storage. Then, group them into three types of activities consist
of value-added activities, necessary but non value added activities, and non-value-added activities. This mapping tool aids to understand the flow of processes, identify the existing wastes, identify whether a process can be rearranged to be more efficient, and identify the improvements can be conducted to increase the value-added activities. The results of PAM analysis are presented in Table 3.

| Table 3. Process activity mapping | Activity |
|----------------------------------|----------|
| Total value-added                | Total    |
| non-value-added                  | 9        |
| added                            | 1200     |
| Percentage (%)                   | 13.6 %   |
| necessary but non-value-added    | 9        |
| added                            | 5280     |
| Percentage (%)                   | 59.8 %   |
| Total                            | 7        |
|                                | 2340     |
| Percentage (%)                   | 26.5 %   |
| Total                            | 25       |
|                                | 8820     |
| Percentage (%)                   | 13.6 %   |
| Total                            |          |

Failure Mode and Effect Analysis (FMEA) is used to identify the failure modes of the wastes. The Risk Priority Number (RPN) is then calculated to each of the failure modes. The results of RPN of the failure modes are presented in Table 4.

| Table 4. Failure mode and effect analysis |
|------------------------------------------|
| Potential Failure Mode |
| Effect of Failure | Potential Causes | Current action | S | O | D | RPN | Solution |
| The paper is broken | Defect | There is no inspection of raw material | - | 8 | 6 | 5 | 240 | Inspection raw material from supplier |
| Glue is less attached | Defect | Poor glue quality | - | 7 | 4 | 5 | 140 | Inspection raw material from supplier |
| The weight of product does not match to standard | Defect | Trouble at mixing process | Inspection on production process not routine | 7 | 4 | 5 | 140 | Improve process |
| Rework | Defect | product | Inspection on production process not routine | 6 | 5 | 4 | 120 | Improve process |
| Set up time too long | Waiting | There is no standard operational procedure | nothing | 8 | 5 | 5 | 200 | Make Operating Procedure and set up time approximately ten minutes |
| Machine breakdown | Waiting | No machine maintenance scheduling | nothing | 7 | 4 | 4 | 112 | Make maintenance scheduling |

The highest failure mode of the cigarettes production process is broken paper with a RPN value of 240. It might be due to poor of raw material quality. It is followed by set up time too long with a
RPN value of 200 and product weight doesn’t match with the standard and glue less attached with a RPN value of 140. It can be seen that the highest failure modes occurred in the cigarettes production process are caused by there is no standard operating procedure, poor the quality of raw material and machine breakdown. The quality inspection is essential to ensure the conformity of materials to requirements. Therefore, should make an effective standard operating procedure and set up time approximately ten minutes, make an effective maintenance schedule and a quality improvement program. Future state mapping illustrated more less time of lead time. It shown that by reducing set up time can reduce delay and waiting time.

4. Conclusion
From the results of the analysis, waste on production process are defect, over processing and waiting. From activity mapping tool obtained the value-added activity (VA) activity mapping obtained the value-added activity (VA) has the lowest percentage of 13.60% and non-value-added activities (NVA) has a percentage of 59.80 which consists of delay activities. Solution to minimize waste are improve inspection process, scheduling maintenance, make standard operation procedure and reduce set up time.

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