Application of lean six sigma to waste minimization in cigarette paper industry

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Abstract. The cigarette paper industry is one of the industry that is always experiencing increasing demand from consumers. Consumer expectations for the products produced also increased both in terms of quality and quantity. The company continuously improves the quality of its products by trying to minimize nonconformity, waste and improve the efficiency of the whole production process of the company. In this cigarette industry, there is a disability whose value is above the company's defect tolerance that is 10% of the production amount per month. Another problem also occurs in the production time is too long due to the many activities that are not value added (non value added activities) on the production floor. To overcome this problem, it is necessary to improve the production process of cigarette paper and minimize production time by reducing non value added activities. Repairs done with Lean Six Sigma. Lean Six Sigma is a combination of Lean and Six Sigma concept with DMAIC method (Define, Measure, Analyze, Improve, Control). With this Lean approach, obtained total production time of 1479.13 minutes proposal with cycle efficiency process increased by 12.64%.

1. Introduction

North Sumatra is one of the tobacco producing areas in Indonesia. Tobacco is the main raw material in the cigarette industry. The growth of the cigarette industry is certainly in line with the growth of the cigarette paper industry, as the two are complementary. This research was conducted on one of cigarette paper manufacture industry in North Sumatera. Based on the results of initial observations in the company obtained the number of defective products produced by the company. The number of defective products produced above the company's tolerance of only 5%. Based on the defect product, it can be seen that the level of efficiency is also low and certainly a lot of waste that occurs during the production process of cigarette paper. This defective product will experience rework that will cause waste of energy, energy and time. Based on the muda in Japan, there are several categories of waste in the industry, namely: rework, over processing, over production, Overproduction consists of making either excessive quantity, waiting and excessive inventory [1,2] . Based on the seven types of waste above, it appears that there is a lot of waste that occurs in the cigarette paper industry. Therefore, it is necessary to take steps to minimize waste in this industry.

One method that can be used to minimize waste is by lean concept. Lean is an approach that seeks to improve flow in the value stream and eliminate waste. Lean concept has various tools to reduce or eliminate waste, one of them is six sigma. [3] The Lean Management tools focus on speed and efficiency of a process, while those of Six Sigma on its precision and accuracy [4] Lean Six Sigma is dedicated to increase quality, reduce variability and eliminate any waste from company [5] By
eliminating waste then production time and production cost can be reduced so that quality can be improved [6] The lean six sigma concept is a combination of lean concepts into six sigma methodology [7] A key component of lean concept for reduction of waste is flow and smart automation [8]

There are many case studies that have used lean six sigma, both in the service industry [9] and in the manufacturing industry. Case studies in the service industry include: in the field of HR administration [10,11] Other studies in health care delivery services industry. Lean Six Sigma projects [12], with projects executed in the following processes [13]: Meanwhile, lean six sigma has also been used in the manufacturing industry Welding wires [14] and Litchi Juice Production Plant of foods and beverage industries in Bangladesh [15]

**Lean Six Sigma**

Lean defined as systematic approach to identifying and eliminating non value add (wastes) through continuous improvement, flowing the product at the pull of the customer in pursuit of perfection. The six sigma define as business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction by some of its proponents [16] The integration between six sigma and lean manufacturing, there is an ongoing trend of integrating Lean and Six Sigma by adding Six Sigma projects to a Lean initiative. The integration of lean and Six Sigma, The phrase “lean Six Sigma” is used to describe the integration of lean and Six Sigma philosophies [17]. Lean and Six Sigma are key business process strategies which may be employed by companies to enhance their manufacturing performance [18]. Integrated Lean Six Sigma (LSS) model for manufacturing industry is illustrated in Figure 1

![Figure 1. Integrated Lean Six Sigma (LSS) model](image)

The implementation of Six Sigma is always done using DMAIC approach In some of the above mentioned references, the five letters abbreviations are simply explained as follows; D: Define, M: Measure, A: Analysis, I: Improve, and C: Control [19,20,21].

Meanwhile, it describes the flow during the production process for the actual condition and after the improvement is by using value stream mapping. Value stream mapping is a method of presentation of material and information flow. It allows identification of all activities from the moment an order has been made by a customer until it is delivered. It also presents both activities which add value and the ones that do not. Activities which do not add any value and are not indispensable for company to operate on the market must be eliminated [22].

**2. Methodology**

This study was conducted on the cigarette paper industry in North Sumatra. This study was carried out by following the six sigma methodology (Define, Measure, Analysis, Improvement, and Control). The first step is to define the process of identifying the flow of cigarette paper production. The define stage is done to study the whole process of making cigarette paper. This stage produces a picture of current state value stream mapping. Current state value stream mapping is used to describe the actual
condition of observation objects based on value added, non value added, and non value added added activities. Classification of company activities provides information on waste / waste that occurs along the flow of production.

Measure stage is done by calculating Manufacturing Lead Time, Process Cycle Efficiency, Process Lead Time, and DPMO, so as to obtain the level of sigma company. The six sigma considers the continuous improvement tool and as the continuous improvement process for reducing variation in process which means the defected products or defected service, which focuses on continuous and breakthrough improvements. Improvement projects are driven in the range of areas and at different levels of complexity, in order to reduce variation. The main purpose of reducing variation on a product or a service is to satisfy customers.

Stages Analysis is done by analyzing the cause of each waste with root cause analysis. This stage is very important to find the process is not appropriate and the cause. In the analysis phase, an evaluation of the current sigma values, production process analysis, information flow, and current problem-causing analysis are presented.

Improvement stage is performed to determine the improvement that will minimize the waste that has been identified. Corrective action is taken to improve the current state. After the selection of alternative improvements, then re-calculation related activities value added, non value added, necessary non value added, Manufacturing Lead Time, Process Cycle Efficiency, Process Lead Time, and DPMO. The goal is to know the positive impact for the company. Furthermore, the Future State Value Stream Mapping.

The last phase is the control phase. This phase is a phase to provide an alternative mechanism of control over the course of alternative improvements. The control phase is the phase to monitor whether the selected repair alternatives are actually applicable.

3. Results and Discussion
In the first phase or phase define, the number of activities that occur during the process of making cigarette paper is sebanyak 48 working processes with a total processing time of 1645.05 minutes. Out of 48 work processes there are 10 non value added activities and 38 value added activities. At this define stage also obtained the number of defective products as much as 702.13 tons during the study took place. The second stage is the measure phase, as for the steps taken is to do:

a. Manufacturing Lead Time Calculation
Manufacturing lead time is the time required to perform the production process from start to finish based on standard time. The calculation of manufacturing lead time is done by summing up the entire working process where in making cigarette paper there are 48 working processes with total processing time of 1645.05 minutes.

b. Calculation of Process Cycle Efficiency
In this calculation, a separation of value added activities or work activities from non-value added activities or work processes takes place. With the separation of these activities, it was found that the time for value added activity was 1119.75 minutes with 20 work processes while non value added activities were 525.30 minutes with 28 work processes. Non value added activities are caused by transportation activities, waiting times, and inspections. Based on the above data, then obtained process cycle efficiency is as follows:

\[ \text{Process Cycle Efficiency} \quad : \quad 68.04\% \]

c. Calculation of Process Lead Time
Process lead time is a metric used to find out how long it takes to process a number of items from start to finish. Calculation process lead time is as follows:

\[ \text{Process Lead Time} \quad : \quad 26 \text{ days} \]

Furthermore, the quality of the product is done by determining the critical to quality and calculating the level of six sigma and DPMO.

1. Critical to quality
Critical to quality is a quality characteristic that affects the moment in the production process and when used by the customer. Characteristics of quality that affect customers are perforated cigarette paper and cigarette lined paper.

2. Calculation of sigma level

Sigma level calculations are performed to unify the quality measurements occurring during the inspection phase which will improve the outcome of the worst process of the inspection phase. Calculation of sigma level is done by following steps.

Total production amount = 5857.44 tons
Total defective product = 702.13 tons
Disability rate (defect per unit / DPU)

DPU : 0.119869
Defect opportunites : 1
Defect per Million Opportunities (DPMO)

DPMO : 119869

Calculation of sigma level is done by using Microsoft excel with formula: = 2.676

From the calculation obtained sigma value of 2.676. This shows that the result is still far from the sigma value to be achieved that is 6 sigma.

The next step is analysis, which aims to increase the sigma value obtained. At this stage it is necessary to identify and analyze the cause of the process that generates waste. To find out the root cause of the problem then used 5 why analysis.

The next stage is improvement, at this stage is done elimination activities that are not value-added. The eliminated activities consist of 8 activities, bringing the total to 40 activities. Activities that are eliminated include:
- Transfer of raw materials to the destruction station is eliminated by placing the raw material near the destruction station.
- Activities waiting to be transported are eliminated by adding a forklift to operate.
- Delay activity for wrapping is eliminated by arranging operator placement while working on packing station.

After 8 activities were eliminated, the time for non value added activities was 359.38 minutes with 20 working processes and total processing time of cigarette paper was 1479.13 minutes. Based on these values, the value of process cycle efficiency can be obtained as follows:

Based on the above calculation, it is seen that process cycle efficiency has increased by 12.64% after elimination of some activities. This happens due to non value added activities that are reduced due to elimination so that the total lead time decreases while. Recapitulation of the details of actual lean metric calculations and proposals can be seen in Table 1.

| Num | Metric                                      | Actual          | Proposed         |
|-----|---------------------------------------------|-----------------|------------------|
| 1   | Number of activities in production activities | 48              | 40               |
| 2   | Total production time                       | 1645.05 minutes | 1479.13 minutes  |
| 3   | Non value added time                        | 525.30 minutes  | 359.38 minutes   |
| 4   | Value added time                            | 1119.75 minutes | 1119.75 minutes  |

Table 1. Recapitulation of Actual and Proposed Leaf Metrics Calculations
The last stage is control. This stage is done by monitoring the result of the proposed improvement by using lean six sigma concept. This stage is needed to assess whether the proposed improvements can actually be applied and can meet the objective of reducing waste that occurs during the production process of cigarette paper.

4. Conclusion
From the current state mapping results obtained 48 activities consisting of 10 non-value added activities and 38 activities of value added. Then after applying the concept of Lean Six Sigma activity can be reduced to 40 activities during the production process. Total production time decreased as much as 165.92 minutes and cycle efficiency process increased by 12.64%.

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