Quality Control Analysis With Lean Six Sigma Approach and Weighted Product Method (case study: XYZ Company)

Khawarita Siregar¹, Aulia Ishak² and Sara Christin³

¹,²,³Department of Industrial Engineering, Faculty of Engineering, Universitas Sumatera Utara, Medan, Indonesia

E-mail: khawarita@usu.ac.id aulia.ishak@gmail.com sarachristin98@gmail.com

Abstract. PT. XYZ is a company engaged in the rubber processing industry. The production process at XYZ company is wasteful in the form of non-value-added activities. The types of non-value added activities contained in the production process are delays (waiting time), transportation, and defective products. In producing packing sterilizer, the company has a defective product that is bent, effervescence, and porous. The percentage of defect is 6.74%. Based on interviews with the company the tolerance given is 5%. This research uses lean six sigma approach and weighted product method. Activities that have no added value are waiting for compound activities to cutting station and transportation for packing sterilizer to cutting station. After estimating the improvement, an increase in sigma level is obtained, namely 3.51 to 3.65.

1. Introduction

In an era of increasingly competitive industrialization, every business person who wants to improve competence in the industry must keep the quality. Attention to quality will give a great impact on business in two ways, the impact on production costs and the impact on revenue. Product quality refers to the ability of a product to perform its functions which include durability, reliability, accuracy, comfort, operation and improvement as well as other attributes [1]. Quality control is an important thing to analysis in order to reduce the rework process carried out as a result of the mismatch of quality specifications produced [2]. The purpose of quality control is to quickly investigate foreseeable causes or process shifts such that an investigation of the process and corrective action can be taken before too many unsuitable units are produced [3]. Lean is a continuous effort to eliminate waste and increase value added products (goods or services) in order to provide customer value [4].

Gustaf [5] reported a study in palm oil company. In this study there are problems in the form of not yet achieved the quality standard of CPO produced which affects the quality of the CPO. In overcoming these problems using the Lean Six Sigma approach. From the results of the analysis of recommendations for improvement in improving the quality of which is to conduct temperature inspections, vacuum dryer machine pressure on a regular basis, limiting the boiling time. DPMO calculation is a good measure for the quality of products and processes, because directly related to the costs and wasting time [6]. Use of six sigma method to reduce the amount of defect and energy used or spent when producing defective products [7].

Agus [8] analyzes the decision making in recruiting new employees, in this study the method used is simple additive weighting and weighted product. Based on the implementation of the method, 10
alternative ranking of prospective workers were obtained as new employees and it was found that the weighted product method was able to provide more accurate results compared to the simple additive weighting method

2. Method
The study was researched at PT. XYZ, where the data taken are defect product during 2019 and cycle time production. The study uses lean six sigma approach and weighted product method. The function of lean six sigma approach are:

- Identify and eliminate non value added activity
- Radical continuous improvement to get 6 sigma process capability
- Flowing products (material, work in process, output) and information using a pull system from internal and external customers
- Pursue excellence and perfection by only producing 3.4 defect for every one million opportunities or operations [9].

The weighted product method uses multiplication to link attribute ratings, where the rating of each attribute must be raised first with the weight of the attribute in question. Determination of the criteria used in the completion of the weighted product method based on key performance index (KPI) indicators. KPI indicators consist of 6 criteria, namely cost, quality, time, facilities, maintenance and services [10].

Data collection is divided into two steps:

- Primary data are production process, production process time, rating factor and allowance.
- Secondary data is the company’s historical data about the company’s general data, data of quality attributes, the amount of production, and the number of product defects.

3. Results and Discussion
There are total defects of packing sterilizer in one year shown in table.1

Table 1. Total defects of packing sterilizer

| Month   | Packing Sterilizer | Type of Defect | Total of Defect | Percentage of Defect (%) |
|---------|-------------------|----------------|-----------------|--------------------------|
|         |                   | Effervescence  | Bent            | Porous                   |                          |
| January | 196               | 6.94           | 7.98            | 5.15                     | 13.59                    | 6.93                     |
| February| 491.34            | 10.48          | 9.03            | 7.77                     | 32.28                    | 6.57                     |
| March   | 299.1             | 6.58           | 7.35            | 5.88                     | 20.13                    | 6.73                     |
| April   | 482.15            | 9.89           | 8.53            | 7.34                     | 30.76                    | 6.38                     |
| May     | 596.85            | 12.42          | 10.71           | 9.22                     | 40.25                    | 6.74                     |
| June    | 370.2             | 9.82           | 9.74            | 5.80                     | 25.36                    | 6.85                     |
| July    | 768.7             | 18.48          | 15.93           | 14.72                    | 50.13                    | 6.52                     |
| August  | 186.4             | 9.31           | 8.44            | 7.61                     | 12.05                    | 6.46                     |
| September| 104.72           | 6.87           | 4.20            | 3.61                     | 7.22                     | 6.89                     |
| October | 460.3             | 11.75          | 10.13           | 9.72                     | 32.6                     | 7.08                     |
| November| 159.71            | 7.33           | 7.60            | 5.96                     | 10.92                    | 6.84                     |
| December| 1,084.09          | 21.85          | 18.84           | 16.22                    | 73.91                    | 6.82                     |
3.1. Define
Define is a step to identify the main problem to be solved. The define phase that will be explained in the form of project statement, product selection, SIPOC diagram, value stream mapping, and voice of customer. Products produced by PT. XYZ consists of 4 types, namely packing sterilizer, car carpet, speed bumpers, and conveyor belts. The product chosen as the object of research is packing sterilizer because this product has the highest number of requests compared to other products.

3.2. Measure
In the measure phase, the calculation of cycle time, normal time and standard time are calculated, lean metric calculation includes calculation of process cycle efficiency, process lead time calculation and process velocity.

3.2.1. Test of Uniformity. Data uniformity testing is carried out to determine whether the data processing time is within the control limits or not on the control map. Control chart for the fourth process, namely grinding RSS rubber material and SBR 1502 on a roll mill mix machine are as follows:

From Figure 5.1, it can be seen that the entire cycle time data for the fourth process is within the control limits.

3.2.2. Data Adequacy Test. After the processing time and load time data that have been tested are declared uniform then a data sufficiency test is carried out to determine whether the data that has been collected has met the amount that should be. The formula used in testing data sufficiency is as follows:

$$N' = \left[ \frac{k}{s} \right] x \sqrt{\frac{\sum X^2 - (\sum X)^2}{\sum X}}$$

(1)

Explanation:
N’ = Number of observations that should have been made
s = Level of accuracy
k = Obtained from the normal distribution table
x = observation time
This is the calculation of the data sufficiency test in the fourth process.
The amount of cycle time data in the fourth process was sufficiently taken during the observation.

3.2.3. Lean Metric Calculation. The lean metric calculation is done to know the condition of a factory from the lean point of view. After knowing the plant's condition through lean metrics, a proposal can be given based on lean principles to improve the plant's condition.

Table 2. Calculation of manufacturing lead time based on standard time

| No | Activities                                                                 | Standard Time (Minute) |
|----|---------------------------------------------------------------------------|------------------------|
| 1  | Preparation and weighing of raw materials to be used using digital scales | 13.91                  |
| 2  | Transference of RSS and SBR 1502 rubber to the roll mill mix machine      | 6.74                   |
| 3  | Entry RSS and SBR 1502 rubber material in the roll mill mix machine       | 11.85                  |
| 4  | Milling RSS and SBR 1502 rubber material on a roll mill mix machine       | 19.21                  |
| 5  | Entry chemical mixtures, namely Minarex B, activator and accelerator      | 4.61                   |
| 6  | Milling of chemicals, namely Minarex B, activator and accelerator until mastication is achieved on the open mill machine | 36.59                  |
| 7  | Entry filler material in the form of CaCO3, TiO2, kaolin and carbon black | 4.65                   |
| 8  | Grinding filler material in the form of CaCO3, TiO2, kaolin and carbon black | 17.25                  |
| 9  | Entry of vulcanizing material in the form of sulfur is in the roll mix mill machine | 3.30                   |
| 10 | Vulcanizing material is in the form of sulfur on a roll mix mill           | 20.84                  |
| 11 | Entry the compound sheet to the quality control station                   | 4.30                   |
| 12 | Quality check compound with hardness tester                               | 4.74                   |
| 13 | Compound waiting to be taken to the cutting station                       | 7.42                   |
| 14 | Entry compound to the cutting station at the mix mill station             | 3.63                   |
| 15 | Cutting compound according to a predetermined size using a bale cutting machine | 5.67                   |
| 16 | Compound waiting to be taken to the vulcanization station                 | 6.49                   |
| 17 | Entry compound to the vulcanization station                              | 0.41                   |
| 18 | Compound assembly to molding machines                                     | 14.38                  |
| 19 | Entry the mold containing the compound to the square press machine        | 1.57                   |
| 20 | Square presses on the mold contain compound                              | 7.02                   |
| 21 | Packing Sterillizer removed from a square press machine                   | 1.73                   |
| 22 | Packing Sterillizer removed from the mold                                 | 1.80                   |
| 23 | Cooling down packing sterillizer                                         | 36.93                  |
| 24 | Packing sterillizer is waiting to be taken to the cutting station         | 4.62                   |
| 25 | Entry packing sterillizer to the cutting station                          | 1.97                   |
| 26 | Cutting the remaining waste in the packing door stew using bale cutting   | 12.32                  |
| 27 | The process of packaging the packing sterillizer manually                 | 2.66                   |
| 28 | Entry the packing sterillizer to the finished product warehouse          | 4.41                   |

Total Manufacturing Lead Time: 261.03

Calculation of Process Cycle Efficiency
In calculating the value of the process cycle efficiency, what must be done first is to separate the activities or work processes that add value from those that do not have value added based on
n the consumer’s point of view. Calculation of process cycle efficiency is as follows:

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

\[
Process \ Cycle \ Efficiency = \frac{214.72}{261.03} \times 100\% = 82.26 \%
\]

Calculation of Process Lead Time
Process lead time is a Lean metric that is used to find out how long it takes to process a number of items from start to finish. Calculation of the process lead time for producing the number of product requests packing sterilizer during 2019 is as follows:

\[
Average \ speed \ of \ completion = \frac{Total \ one \ year \ production}{Working \ days}
\]

\[
Average \ speed \ of \ completion = \frac{5199.56}{293} = 17.74 \text{ kg/day}
\]

\[
Process \ Lead \ Time = \frac{Number \ of \ Products \ in \ Process}{Average \ speed \ of \ completion}
\]

\[
Process \ Lead \ Time = \frac{5199.56}{17.74} = 293 \text{ day}
\]

Process Velocity
Process velocity is the speed of the process of producing a number of goods from beginning to end. Process velocity calculation is as follows:

\[
Process \ Velocity = \frac{Number \ of \ activities \ in \ the \ process"}{Process \ Lead \ Time}
\]

\[
Process \ Velocity = \frac{28}{293} = 0.096 \text{ process each day} = 0.0040 \text{ process each hour}
\]

3.2.4. Sigma Level Calculation. The sigma level calculation is performed to unify the quality measurements that occur at the inspection stage so that it can be compared which inspection stage is in the worst condition. In addition, improvements will also be made to the process that results in the worst inspection stage. Sigma calculation is done using the following steps:

- The total number of production units produced = 5199.56
- Total of defect product = 349.20
- Defect Per Unit (DPU)

\[
DPU = \frac{Total \ Defect}{Total \ Production \ Unit}
\]

\[
DPU = \frac{349.20}{5199.56} = 0.0672
\]

- Defect opportunities (CTQ) = 3
- Defect per Million Opportunities (DPMO)

\[
DPMO = \frac{DPU}{CTQ} \times 1.000.000
\]

\[
DPMO = \frac{0.0672}{3} = 22.386,5096
\]

- Sigma level calculation
From the data above, DPMO is found between 22,215 and 22,750 and sigma values between 3.51 and 3.50, then interpolated to get sigma level.

\[
(DPMO - X_2)(X - Y_2) = (X_1 - DPMO)(Y_1 - X)
\]

\[
(22.386,5096 - 22.215)(X - 3.51) = (22.750 - 22.386,5096)(3.50 - X)
\]

\[
X = 3.51
\]
3.3. **Analyze**

At this stage an analysis will use a cause and effect diagram (fishbone diagram) and a five why diagram which serve as a tool to further analyze the results obtained at the Measure stage.

![Figure 3. Cause and effect diagram of effervesce defect](image1)

![Figure 4. Cause and effect diagram of bent defect](image2)
3.4. Improve
Multiple Attribute Decision Making (MADM) concerns choice issues, where mathematical analysis is not too much needed or can be used for the selection of only a small number of alternatives. There are several methods that can be used to solve problems one of them is Weighted Product Model (WPM).

Table 3. Recapitulation of alternative improvements in the production process

| Category       | Alternative                                      |
|----------------|--------------------------------------------------|
| Material       | Checking raw materials                          |
| Method         | Periodic SOP checks                             |
| Machine        | Make a schedule of cleaning and maintenance of the machine |
| Operator       | Supervise operators                             |
| Environmental  | Add a fan in the work station                    |

3.5. Control
In the analysis phase above, in order to ensure that the proposed improvements that have been made can run well, it is necessary to make a work procedure that is a reference for the operator in carrying out production activities. In the production process it is known that the main source of product defects is due to the process of importing and grinding raw materials and the vulcanization process.

4. Conclusion
Based on the results and discussion conducted above, it can be concluded that:

- Lean six sigma approach used to find the activities that have no added value there are compound activities waiting to be taken to the cutting station and transferring and transferring the packing sterilizer to the cutting station
- The value of manufacturing lead time, process cycle efficiency and initial process velocity data are 261.03 minutes, 82.26% and 0.0040 processes / hour, respectively. After making improvements and estimations, manufacturing lead time, process cycle efficiency and process velocity values are obtained 243.38 minutes, 88.22% and 0.0034 processes / hour, respectively. After estimating the improvement, an increase in sigma level is obtained, namely 3,51 to 3,65
- Using weighted product method there are actions obtained from the greatest weight on raw material checking materials, on the method of periodic SOP inspection, on machines / equipment making cleaning schedules and machine maintenance, on operators conducting surveillance, on the environment adding air conditioner.
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