Reducing waste in production process with lean six sigma approach and weighted product method

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Abstract. PT XYZ is a company engaged in the production of pesticides. There are some problems in production process that cause inability to full fill the production quantity target without doing overtime. the problem is the existence of activities that are not value-added and products defect. There are 48,73 % non value added activity and in 2017 the average of products defect reaches 3.89% of total production. This can affect the quality of the products produced to compete with similar companies. This problem is solved by Lean Six Sigma approach. Based on research conducted Lean current condition is PCE (Process Cycle Efficiency) equal to 51,27%, process velocity equal to 0,082 process / hour. The research shows that quality performance at the first phase inspection was 3.77 sigma, on phase II was 3.85σ. The most common product defect is a leaky bottle, an oblique stamp, a torn / wrinkled label and a missing / blurry label. The proposed improvements are the application of the 5S and weighted product method. Based on estimation result, the process cycle efficiency and process velocity was increased to 55.07% and 0.071 process /hour respectively, Quality performance in the inspection phase I is 4.20 σ and on phase II is 4.40 σ.

1. Introduction

Indonesia is an agrarian country with 41% of Indonesian workforce in agriculture and plantation. As an agricultural country, the need for fertilizers and pesticides is quite high in Indonesia. The demand is high enough to make the competition of the fertilizer and pesticides industry more competitive. The quality of the product becomes a matter of concern for the company. The ability of companies to provide quality products will be an advantage to win in a competition. Quality is a measure of how well a goods or services meet the needs of consumers in accordance with certain standards. They may be related to time, materials, performance, reliability, or quantifiable characters [1]. To meet customer satisfaction, the company must be able to produce products in accordance with the needs and desires of customers. In general, the company has a department quality control that is responsible for product quality issues.

PT XYZ is a manufacturing company engaged in the pesticide industry. The company produces pesticides from the formulation process to the final process (packing) of the finished pesticide. The company produces two types of pesticides namely insecticides and herbicides. The production process at PT XYZ is having problems waste(waste) which is the number of defects(defects) in the form of packing leak, no information most print on the packaging or label, the label folded / creased, torn label, the label is missing or faded prints, cap askew and found no(non
value added activity) non value added activity. Based on the above conditions, it is necessary to do better quality control in PT. XYZ using approach Lean Six Sigma. Identification of waste (waste) is done from two aspects: Lean and Six Sigma.

Previous research on reduction is waste done in PT Coca Cola Amatil Indonesia [2]. In this research, there are three types of defective products: cap, cap quality and underfill. The problem is solved using concept Lean Six Sigma using tools pareto and diagram fishbone. From the analysis using tools these, the company is advised to provide training on time management on its employees, especially on new employees, as well as performing more routine machinery checks and pay more attention to the production area environment.

Boniface Yorie analyzed the causes of delays in production targets and defective product spare parts at PT Sinar Agung Selalu Sukses [3]. The problem is analyzed using concept Lean Six Sigma and Weighted Product. Based on the research, sigma level is found below 2.35 so that it is done by reducing waste based on the most influential CTQ. Improvements made are improvements layout, change the container and making SOP. At the stage control obtained recommendation improvement of production schedule for the flow of production process can run smoothly and production target fulfilled.

2. Research Method
The research was conducted at PT XYZ in May 2018 until June 2018. The observed object was Dursban size 1 L. The data used were divided into 2 types, namely:
a. Primary data is data obtained from direct observation, interview and direct measurement in the field. Primary data collected include sequence of production process, production process time, machine load time, alternative rating and criteria on weighted product.
b. Secondary data is data obtained from the company that is attribute quality data, attribute defect count and general company data.

The steps undertaken in this research is starting from identifying problems that occur in production. Then do a preliminary study to know the problem-solving method. Data collection is done to be used as input in research. Data processing using Lean Six Sigma to analyze the quality control of pesticide.

3. Results and Discussion
The steps of the Lean Six Sigma method for analyzing the production process of pesticides used in data processing are Define, Measure, Analyze, Improve and Control [4].

3.1. Define
This phase is to identify the main problem to be solved. The phase define will be explained in the form of project statement (project statement), product selection, SIPOC diagram, and Voice of Customer. The product to be the object research is the product that has the highest number of requests, namely dursban size 1 Liter.

3.2. Measure
3.2.1. Calculation of Standard Time
Calculation of standard time begins by testing the data uniformity and adequacy of data. Based on the calculation, it is obtained that the data of measurement time is uniform and sufficient.

3.2.2. Processing of Product Quality Data
The quality characteristics of each stage of inspection are as follows:
a. Inspection Phase I
   Type of defect occurring at the first stage inspection is as follows:
   1) Leaking Package (KB), that is physically of product damaged on the product lid.
   2) There is no information batch number most printed on the bottle (TI)
3) The stamp inclined (CM), the position of the sloping bottle cap that may lead to the potential of the spill product.

b. Inspection Phase II

Type of defect that occurs in the inspection phase II are as follows:
1) There is no information batch number most printed on the label (TI)
2) Label torn / wrinkled (LK), the label on the bottle torn due to errors on the labeller bottle machine.
3) Labeling is missing / blurred (LH), ie writing on labels is missing / unclear so information about product is not clear.

Performed calculations of DPMO and sigma levels for each inspection, and obtained as follows.

| Table 1. Sigma Level for Inspection Phase I and II |
|-----------------------------------------------|
| Sigma Level for Phase | Sigma level for Phase |
|-----------------------|------------------------|
| DPMO                  | DPMO                   |
| 11.307                | 9.580                  |
| Sigma Level           | Sigma Level            |
| 3.77                  | 3.85                   |

3.3. Analyze

In the analyze stage done calculation of lean metrics, making pareto diagram, cause and effect diagram why why.

3.3.1. Lean Metric

Measurement of lean metric will give a preliminary picture of the company's condition before it is applied Lean [5]. Calculations of metrics lean that include calculations manufacturing lead time, calculation process cycle efficiency, and calculation process lead time and process velocity. To calculate process cycle efficiency, process lead time, process and velocity:

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

(1)

\[
\frac{157,239}{306,716} = 51.27\%
\]

Average of speed completion = \[
\frac{\text{Total Production per month}}{\text{Number of working days}}
\]

(2)

\[
\frac{76231}{17} = 4,485 \text{ units / day}
\]

Process lead time = \[
\frac{\text{Work In Process}}{\text{Average of speed completion}}
\]

(3)

\[
\frac{76,000 \text{ units}}{4,485 \text{ units/day}} = 16.95 \text{ days}
\]
Process velocity is the speed of the process in producing a number of items from the beginning to the end. The calculation of process velocity is as follows:

\[
\text{Process Velocity} = \frac{\text{Number of production activity}}{\text{Proses lead time}}
\]

\[
= \frac{32 \text{ proses}}{16.55}
\]

\[
= 1.65 \text{ process / day}
\]

\[
= 0.082 \text{ process / hour}
\]

Value stream mapping is a visual method for mapping the production line of a product that includes material and information from each work station [5]. Value stream mapping can be a starting point for companies to recognize waste and identify the cause. The Value Stream Mapping current state, can be seen in Figure 1.

3.3.2. Pareto Diagram

Pareto diagram showing the defect sequence of each defect attribute. The pareto diagram of the inspection Phase I can be seen in Figure 2.

Based on the 80-20 rule, the type of defect in the first phase inspection that should be analyzed further is the type of defect having a cumulative percentage below 80%, ie

a. Leakage Package (KB) with a cumulative percentage of 43.7%

b. Capping Italic (CM) with a cumulative percentage of 72.8%
Pareto diagram of inspection phase II can be seen in Figure 3.

![Pareto Diagram on Inspection Phase II](image)

**Figure 3. Pareto Diagram on Inspection Phase II**

Based on the 80-20 rule, the type of defect in the second phase inspection that should be analyzed further is the type of defect that has a cumulative percentage below 80%.

a. Labeled / Lulled (LB) with a cumulative percentage 40.4%
b. Label with missing percentage of 72.6%  

3.3.3. Problem Identification with Fishbone Diagram

Based on observation result on production floor of pesticide production process, there are several main factors causing product defect made in Fish Bone Diagram.

3.3.4. Why-why

*Why-why* is a diagram used to express the root of the problem of the cause of nonconformity, obtained from the fishbone diagram to be corrected correctly by asking constantly why a discrepancy occurred until the root of the problem was discovered.

a. inspection I

Analysis of the causes of the occurrence of defects leaking bottles can be seen in Table 2.

**Table 2.** Table Why Why on Bottle Leaking

| Problem       | Why                        | Why                              | Why                              | Why                              |
|---------------|----------------------------|----------------------------------|----------------------------------|----------------------------------|
| Bottle leak   | Bottle that is used not according to specification | Bottle defects pass inspection materials | Inattentive operator | Less experienced operator | Lack of supervision |
|               | *Heater* machine is sealing not working | Lack of maintenance | Maintenance program fails | Improper planning | No work procedure |
|               | Bottle drop                | Operator less concentration      | Less comfortable room | Lack of lighting | Lamp on the production floor is damaged |

Analysis of the causes of the occurrence of disablement caps can be seen in Table 3.

**Table 3.** Table Why Why on Italic Capping

| Problem       | Why                        | Why                              | Why                              | Why                              |
|---------------|----------------------------|----------------------------------|----------------------------------|----------------------------------|
| Stamp         | Cap is used not according to specification | Stamp size does not match bottle | Variation of cap sizes | Different suppliers | Difficulty obtaining seal |
|               | *Heater* machine sealing does not work | Lack of care | Improper planning | Machinery is old | No work procedure |
|               | *Capping* improper          | Operator is not thorough          | Operator less experienced Operator | Lack of training on operator | Lack of supervision by shift leader |
b. Inspection stage II

Analysis of causes of the occurrence of label defects can be seen in Table 4.

**Table 4.** Table Why Why on Torn Label Defect

| Problem          | Why                  | Why                     | Why                     | Why                     | Why                  |
|------------------|----------------------|-------------------------|-------------------------|-------------------------|----------------------|
| Thin label       | Quality label decreased | Variable label thickness | Supplier error          | Poor Communication with supplier |
| Rollers slack label player | Mur roller player less tight | Machines are old | Lack of maintenance | No work procedures |
| Operator is not thorough | Less responsible | The operator less experienced | Lack of job training on operator | Lack of supervision by shift leader |

Analysis of the cause of the missing label writing / blurred can be seen in Table 5.

**Table 5.** Table Why Why on Disabling Lost / Faded Writing

| Problems           | Why                  | Why                     | Why                     | Why                     |
|--------------------|----------------------|-------------------------|-------------------------|-------------------------|
| Missing /tags fuzzy | Label Label used damaged | Label exposed to water | There is water in storage | Place label storage clean |
|                    | roomless comfortable | There is a pile of garbage | Workers do not regularly clean the area and equipment | Lack of supervision on the production floor |
| Wet bottle         | The remaining fluid on the spill nozzle | Operator is not thorough | Operator less responsible | Lack of supervision by the shift leader |

3.4. Improve

To improve the production process at this stage used the method 5S and weighted product.

3.4.1. 5S

Improvements using the 5S method is a program to improve workplace, process, and product convenience by involving operators working during the production process [6]. The 5S method is the basis of continuous improvement (kaizen), which consists of a series of activities to eliminate waste that causes errors, disabilities, and workplace accidents.

3.4.2. Weighted Product

Weighted product is used to obtain a proposed improvement, with an alternative that has the highest weight as an option [7]. Based on the calculation using the weighted product obtained an alternative improvement in the production process, as shown in Table 6.

**Table 6.** Recapitulation of Alternative Improvements on Production Process

| Category          | Alternative                                      |
|-------------------|--------------------------------------------------|
| Material          | Checking the quality of packaging before the process begins |
| New Methods       | SOP Making                                       |
| Machinery / Equipment | Adding frequency of schedule maintenance       |
| Operator          | Conducting training to the operator on a regular basis |
| Environment       | Adding lighting on the production floor          |
3.4.3. An Estimates

On aspect Lean that becomes the main waste is transportation. If the transport time can be shortened, then the process cycle efficiency can be improved. Future value stream mapping can be seen in figure 8. Therefore, the proposals given are as follows:

1. Eliminate the 2nd activity (transfer of materials to the area pumping). To eliminate this activity is done by setting the laying of work stations, namely by making the area pumping right after the digital scales. Thus, the operator on the weighing section does not need to move the material to the area pumping.

2. Eliminate the 24th activity (removal of bottles to the inspection area). This activity is eliminated by inspecting the product in the numbering area on the label.

3. Eliminate the 30th activity (moving the product onto the pallet). This activity is eliminated by setting the laying of the work station, ie by moving the pallet right after packing process and the process of moving the product onto the pallet is done directly by the packing operator. Thus, the wrapping operator will directly lift the product to the wrapping area.

As for the aspect six sigma to be proposed improvement is the result of weighted product. The company is committed to implement the proposed improvement with the percentage of success in the inspection stages I and II respectively 70% and 80%.

Based on the calculation after the improvement results obtained the following estimates:

| Metric | Lean | Before | After |
|--------|------|--------|-------|
| Number of production activities | 32 processes | 29 processes |
| Manufacturing Lead Time | 306,716 seconds | 285,552 seconds |
| Value-Added Time | 157,239 seconds | 157,239 seconds |
| Non Value-Added Time | 149,476 seconds | 128,312 seconds |
| Process Cycle Efficiency | 51.27% | 55.07% |
| Process Velocity | 0.082 process / hour | 0.071 process / hour |

Quality of Product

| Characteristic CTQ (Critical to Quality) | Before | After |
|----------------------------------------|--------|-------|
| DPMO | 11306.7 | 3.392 |
| Sigma Level | 3.77 | 4.20 |
| Capability Process | 0.966 | 0.990 |

| Characteristic CTQ (Critical to Quality) | Before | After |
|----------------------------------------|--------|-------|
| DPMO | 9.580.04 | 1.916 |
| Sigma Level | 3.85 | 4.40 |
| Capability Process | 0.971 | 0.994 |

3.5. Control Phase

To ensure the proposed improvements can run well, it is necessary to create a working procedure that governs the operators, machines, and methods in the process of working. In the production process known that the source of product defects are sealing, capping, and labelling machine. Error methods in these three processes lead to the emergence of defective products. Therefore, it is necessary to perform standard operating procedures for the process.
4. Conclusion
The result of data processing and problem analysis give some conclusion as follows:
1. Applying concept Lean in pesticide production process gives improvement to pesticide production system by reducing waste in the form of non-value added activity. The value of process cycle efficiency and process velocity of initial data were 51.27% and 0.082 process / hour respectively. After the improvement and estimation, the obtained process cycle efficiency and process velocity are equal to 55.07% and 0.071 process / hour.
2. The use of the method weighted product for improvement on Six Sigma provides increased sigma value at each stage of inspection of defective products. After improvement estimation, the increase in sigma level is 4.20 from 3.77 and 4.40 from 3.85.
3. Proposed improvements given to the pesticide production process are corrective measures derived from the greatest weight on the weighted product method, the application of 5S, work place management and the preparation of Standard Operation Procedure (SOP) of sealing, capping, and labeling processes.

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