Quality control analysis to reduce defect product and increase production speed using lean six sigma method

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Abstract. CV. Naga Mas engaged in manufacturing spare part. Support assy is one of the products that manufactured by the company. The product has an average disability percentage 9.49% of the total monthly production which exceeds the limits of the company. This study propose to increase production speed by to eliminate non value added activities and reduce the amount of disability products through design improvements. This problem solved with Lean Six Sigma approach with the combination Lean and Six Sigma concepts by using DMAIC steps to propose improvements through eliminate non value added activities and reduce the amount of defective products. Proposed improvements given that eliminate non value added activities and micro layout redesign settings. Based on estimates, the result for the process lead time reduction is 22.01 min/ cycle process, increasing process efficiency and process cycle velocity, respectively for 7.80% and 0.0008 processes / h. Improvement plans are using 5S method such as sorting, arrangement, cleaning, consistency and self discipline that makes work programs in making machines, makes work procedures, inspects raw material, improves communication with suppliers and manages regular machine maintenance.

1. Introduction
In the era of industrial revolution 4.0, the industrial sector is not enough just efficient, but it must be creative, innovative, effective and adaptive. Industry 4.0 is an integrated industrial era where products produced with automation technology without the need for human intervention. Standardization become increasingly important in all sectors, especially now the digital era. To overcome the gap that is widening as a result of very rapid change, the concept of industrial 4.0 has a positive opportunity to the manufacturing industry such as production flexibility, increase production speed, improve product quality, lowering the average failure and optimize efficiency. Industrial 4.0 has a high sensitivity level so as to produce a very good quality. Quality is an important element that must be met by the company, because the quality is fulfilling the needs of the service and provided to consumers. Therefore, the manufacturing industry is required to produce a quality product in a way that is most efficient and effective.

Naga Mas is a company engaged in the production of vehicle spare parts. Support assy is one of the products that manufactured by the company. In the manufacture of spare parts, CV. Naga Mas experiencing problems waste (waste) that is the product defects (defects) in the form of products uneven surface, bloated and perforated, and there is no value-added activities (non-value added activities). Data on the number and percentage of product defects support assy during 2018 can be seen in Table 1.
Table 1. Total disability products support assy in 2018.

| Month    | Production (Unit) | Total Disability (Units) | Disability Percentage (%) |
|----------|-------------------|--------------------------|---------------------------|
| January  | 41 350            | 3987                     | 9.64                      |
| February | 42 165            | 4121                     | 9.77                      |
| March    | 42 860            | 3969                     | 9.26                      |
| April    | 42 740            | 4154                     | 9.72                      |
| May      | 40 840            | 3872                     | 9.53                      |
| June     | 42,710            | 4070                     | 9.48                      |
| July     | 42 750            | 3947                     | 9.23                      |
| August   | 39 140            | 3671                     | 9.38                      |
| September| 41 570            | 4108                     | 9.88                      |
| October  | 42 840            | 4144                     | 9.67                      |
| November | 42 200            | 3918                     | 9.28                      |
| December | 41 815            | 3794                     | 9.07                      |
| **Total**| **502 980**       | **47 755**               | **113.93**                |

Average: 9.49

Based on Table 1, it can be seen disability support assy average percentage is 9.49%. After interviews with the company, it is known that the company wants the percentage of disability of the product below 5%. It is therefore necessary repairs due to defects that can affect the amount of output produced by the company. There are inefficiencies or waste that occurs in the production system because there is a waiting time (waiting time) effect on the production cycle time. In addition, there is no standard procedure as reference work in production can also lead to disability. One of the corrective measures that can be used is to use Lean Six Sigma approach.

2. Quality

Quality is a measure of how well a product or service to meet customer needs based on certain standards. Quality constituted with sight unseen customers. While other requirements defined by translating the characteristic that the company producing the product to the specifications set. Quality is also a specification conformance and conformance level is a measure of quality. If the specifications do not satisfy the needs of customers, specifications should be changed [1].

3. Lean six sigma and 5S

Lean Six Sigma is a fusion between Lean and Six Sigma concepts, so it can be defined as a business philosophy, a systemic approach and systematic that waste or not value added activities can be identified and eliminated through the continuous improvement to achieve the level of performance of six sigma. Lean Manufacturing is an efficient approach that is done so that the waste can be eliminated and the process can be changed. That can be done by analysing and reduce the waste using continuous improvement [2]. Lean Manufacturing has the goal of creating an efficient production system by eliminating waste so as to increase product value [3]. Six Sigma is a comprehensive and flexible system in order to provide and achieve support and business processes can be maximized and focuses on understanding of customer needs based on fact [4]. Lean Six Sigma used tools to eliminate waste (waste) and increase efficiency by eliminating or reducing defect and reducing operational variability [5]. Lean aims to analyze and discard non value added activities compilation of production systems in progress, [6]. Nine types of waste consist of Defect, Environmental, Overproduction, Health, and Safety (EHS), Not utilizing knowledge and Waiting employees [7].

Six Sigma concepts to make continuous efforts in order to minimize defects (defects) by reducing the variations that occur during the production process, thus maximizing the process / product are within the control limits. Implementation of Six Sigma to improve the quality of products consists of five phases of DMAIC (Define, Measure, Analysis, Improve and Control) [8]. Value stream mapping (VSM) is a method used in the application of lean manufacturing. Value streams map all activities that include
added value and not added value, the main flow of the process will be to bring products or groups of products that use the same resources from raw materials to finished products that will be distributed to consumers [9].

5S is a method used to overcome and reduce the waste that occurs in the company, with the 5S companies can reduce excessive inventories as well as establishing the organization and also reduce the lead time [10]. 5S consists of Seiri, Seiton, Seiso, Seiketsu, Shitsuke which is an effort to organize the work area by means of identifying and putting a tool that really necessary, maintain the cleanliness and tidiness of the work area and work tools as well as the maintenance of order, in order to create a work area that is clean, efficient and safe to increase productivity [11]. To reduce defects in the product can be applied Standard Operating Procedure (SOP). SOP is a reference that include the standard operating procedures. SOP aims to make sure some actions or decisions in the use of the facility carried out by people within an organization to run effectively, standardized and systematic [12].

4. Methodology
The study was conducted at CV. Naga Mas month of March 2019 to July 2019. The research object observed is support assy. The data used was divided into 2 types:
1. Primary data is data receive by researchers directly, interviews and direct measurements in the field.
   Primary data gather including sequence of the production processes, production process time, load time machine and set-up time data engine, rating factor and allowance.
2. Secondary data is data receive from the company that is the attribute data quality, the number of disability attributes and common data company.
   The steps in this study begin with a discussion of the problems that occur during production so that a preliminary study is carried out in order to determine the method for solving the problem. Data collection is done in order to process the data. Then processing the data such as analyze support assy quality control using Lean Six Sigma method.

5. Result
5.1. Define
Define phase starts with identifying the main problems. At this stage the project statement (statement of the project), product selection, SIPOC diagrams, as well as the Voice of the Customer will be describe. Products that will be the research object is support assy because it has the highest demand product.

5.2. Measure
5.2.1. Calculation standard time
Start standard time calculation to test the consistency and the adequacy of the data. Based on the calculation, obtained that measurement time data uniformly and fairly. Then do the depiction of the flow of the production system in CV. Naga Mas using Value Stream Mapping.

5.2.2. Lean metrics actual
The calculation of metrics consisting of lean manufacturing lead time calculations, process cycle efficiency, process lead time and process velocity. The separation of the value added and not value added activities to perform the calculation process cycle efficiency, process lead time, and velocity process.

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

\[
\text{Process Cycle Efficiency} = \frac{120.20}{195.44} \times 100\% = 61.50\%
\]

Average speed of completion = \[
\frac{\text{Total Production in a month}}{\text{Number of Working Days}}
\]
Average speed of completion = \( \frac{502980}{292} = 1723 \text{ units/day} \)

\[
\text{Process Velocity} = \frac{\text{The amount of activity contained in the process}}{\text{Process Lead Time}}
\]

\[
\text{Process Velocity} = 0.137 \text{ process/day} = 0.0057 \text{ process/hour}
\]

5.2.3. Data processing product quality

The characteristics Critical to Quality (CTQ) of the examination are as follows:

a. Uneven Surface (S) is a disability where there has uneven surface in support assy.

b. Bloat (G) is a disability where there is a convex surface as there are air bubbles in the rubber support assy.

c. Perforated (B) is a disability where there is an imperfect form in the rubber support assy.

Calculation of the value of DPMO and sigma level for examination and obtained as follows.

a. The total number of production units produced = 502 980

b. Total product defective = 47 755

c. The level of disability (Defect Per Unit / DPU)

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

\[
DPU = \frac{47.755}{502.980} = 0.0949
\]

d. Defect opportunities or Critical To Quality (CTQ) = 3

e. Defect per Million Opportunities (DPMO)

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

\[
DPMO = \frac{0.0949}{3} = 31648.0443
\]

f. Sigma level calculation by interpolation

From the above data obtained DPMO is between 31 443 and 32 157 and sigma values between 3.36 and 3.35, then do interpolation to get the DPMO sigma level of 32587.1539,

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

\[
(31,648.0443-31 443) * (X-3.36) = (32 157 -31,648.0443) * (3.35-X)
\]

\[
X = 3.36
\]

g. Calculation of sigma level

\[
\text{Sigma Level} = \text{NORMSINV} \left( \frac{1-DPMO}{1000000} \right) + 1.5
\]

\[
= \text{NORMSINV} \left( \frac{1-31,648.0443}{1000000} \right) + 1.5
\]

\[
= 3.36
\]

Sigma level obtained through the calculation of sigma value of 3.36 with DPMO 31648.0443, this indicates that for every one million times the production of the likelihood of disability is 31 648. Identification and analysis of the causes of the process that produces defective products so as to provide a solution that fixes sigma level can be improved.

5.3. Analyze

5.3.1. Pareto diagram

Pareto diagram is a way of weighting the various types of events or issues outstanding in a production process, which is based or the starting point to the fact that all the problems can be classified in a vital, which are few in number, and one that is trivial or not hard polynomial [13]. Sequence of disability of each attribute of disability can be mapped through Pareto diagram and can be seen in Figure 1.
Type of disability that must be analyzed is the type of disability that has a cumulative percentage below 80% (Based on 80-20 rules), namely uneven surface (S) with a cumulative percentage of 46.4% and bloated (G) with the cumulative percentage of 74.6%.

5.3.2. *Cause and effect diagram*

The analysis of a causal diagram includes human analysis, working environment, machinery and equipment, working methods and material to attribute acquired disability.

5.3.3. *Five why diagrams.*

*Five* Why is a technique used to find the root cause of the problem by repeating the question “why” 5 times to find problems that can be improved [14]. Data for charting five disability is why for the attribute data obtained from the causal diagram and observations on the production floor as well as brainstorming with the company.
5.4. Improve
After conducting an analysis using Five diagram, found the cause of disability in the problem that there was no training for use of the machine, no working procedures based on standards (SOP), no inspection of incoming raw materials, lack of communication with the suppliers, lack of ventilation factories and companies are still applying corrective maintenance. 5S method is used to fix the problem.

5.4.1. 5S
Improvement using 5S is as follows:
1. *Seiri* (Sorting), with separate pieces, pieces of rubber, or reject products that are not used while on the production floor in one area such as screwdrivers, wrenches, wrenches and grease separated by type and placed near the engine.
2. Seiton (Setup), with the following such as: Given a visual mark on each box shelters are at each station so that it can put and carry debris and pieces of rubber were found on the production floor to production support assy, located near the engine so that the bits and pieces resulting from the machining process can be cleaned, equipment for the repair of machines such as screwdrivers.

3. Seiso (Cleaning), with the following such as: all operators are required to sweep the floor, emptying trash, cleaning the areas of equipment, cleaning machines of the remaining scrap, cleaning up oil spills and reporting unsafe conditions and also make a schedule containing the cleanliness of responsibility, the area is cleaned, the frequency of cleaning.

4. Seiketsu (Stabilization), with the following proposals such as operator training, machine and equipment maintenance.

5. Shitsuke (Habituation), by applying the discipline to each employee so that workers see it as a corporate culture that must be carried out continuously.

5.4.2. Information
There’s waste because the information that is submitted to the supplier is not timel. At this time, the quality of the raw materials obtained from suppliers sometimes they can lead to production defects if too soft because the quality of the raw materials are inadequate by the supplier. Proposed improvements that can be proposed is to increase and maintain communication between the company with the supplier, so as to obtain raw materials of the highest quality, in addition to the necessary raw materials quality inspection before going into production.

5.4.3. Results estimates
Transportation is a major factor in waste. The efficiency of the production cycle can be improved if prepared. The proposal is given such as eliminating activity rubber support assy waiting to be taken to the abattoir, eliminating activity iron plate waiting to be taken to a hydraulic press machine iron and eliminating activity iron plate waiting to be brought to the drilling machine.

| Lean metrics                  | Before          | After           |
|-------------------------------|-----------------|-----------------|
| Total production              | 40 process      | 34 process      |
| Manufacturing Lead Time       | 195.44 minutes  | 173.43 minutes  |
| Value-Added Time              | 120.20 minutes  | 120.20 minutes  |
| Non Value-Added Time          | 75.24 minutes   | 53.23 minutes   |
| Process Cycle Efficiency      | 61.50%          | 69.31%          |
| Process Velocity              | 0.0057 processes/h | 0.0049 processes/h |

5.5. Phase control
In the previous analysis phase, the main problems in the production process support assy is the raw material grinding process, the formation of compound form of rods, rubber molding and cutting the iron plate. Disability production is caused by a lack of training in the use of machinery and tools, the absence of procedures for using the machine and lack of engine treated and cleaned because the company is still applying corrective maintenance, to overcome this problem can be solved by creating a working procedure that good at the work station and machine problematic and the need to implement preventive maintenance in engine maintenance.

6. Conclusion
The results of data processing and analysis for troubleshooting give some conclusions as follows:
1. Application of Lean concepts in the production process support assy provide improvements to the production system does support assy with reduction of waste in the form of value-added activity (non-value added activity) in the form of a transfer and waiting times. Value process cycle efficiency...
and process the actual velocity respectively by 61.50% and 0.0057 processes / h. After repairs and do estimates, the value of process cycle efficiency and process velocity respectively by 69.31% and 0.0049 processes / h.

2. Proposed improvements provided in the production process, namely the support assy corrective action in the form of implementation of 5S, improvement of layout and manufacture Standard Operation Procedure (SOP) process of entering and grinding of raw materials, the process of forming compound rods, rubber molding process, steel plate cutting process.

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