Quality control analysis of t-shirt production process to increase company productivity by using six sigma-dmaic method case study of gareng t-shirt convection yogyakarta

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Abstract. Quality control is very important for Gareng T-shirt Convection. Gareng T-shirt Convection has realized about the quality control to avoid defects in the process of T-shirt production. One of the methods that used to improve the quality control is by using Six Sigma-DMAIC. The aim of this method is to minimize the defect which can decrease in each period. This research is doing to the Convection Company named Gareng T-shirt. The company is expected to provide tourists satisfaction as handicraft of Yogyakarta. The data is acquired by collection the number of product defects that occur in every process of t-shirt production about the last three years, from 2014-2016. The results of this research in the process of T-shirt production is there are a lot of defects such as packaging, stitching on the fabric, screen printing, and cutting. The Calculations of the defective product can be known by DPMO value that is 1,975 units with a sigma level 3.10. The results of the RPN assessment are two processes which have the big RPN value in the production of t-shirts they are screen printing process (RPN 596) and packaging (RPN 512). The analysis is using fishbone diagram and FMEA method; it is proposed to improve the quality of human resources for the company.

1. Introduction

Increasingly intense competition in the globalization era causing any company required to compete with other companies, especially in the fields of manufacturing and services. Every company has competitors producing similar products. This situation resulted the company should improve the quality of its products in order to remain able to capture consumers.

Research of the year 2013 with the title "Quality Improvement with the application of the proposed method of Six Sigma and FMEA (Failure Mode and Effect Analysis) on the production process of Roller Conveyor MBC PT. XYZ". Describes the proposed improvements that are determined based on the results of the assessment of the SOD and the value of the RPN in the analysis. Calculation based on data from the defective product, DPMO values is 8,634 unit with sigma level of 3.88 sigma. Based on the analysis done using the fishbone diagram and method of FMEA, quality improvement proposals for the acquired company[1].

Previous research showed that the problems occurred in CV. The miracle that is, about the condition of the quality of products that are less noticed. Especially on the quality of the process screen printing. The quality control process of screen printing based only on the specification of the form the shape of the image. While the image quality and color of the results of screen printing on mica is not so aware

of. To address the problems in the study of quality control methods used then by applying six sigma method. Six sigma is a process improvement that is sustainable. Quality improvement process six sigma include process Define – Measure – Analyze – Improve – Control (DMAIC). The repair process that produces a value of sigma which increased by 2.05 and DPMO declined by 290,741. Cost of Poor Quality due to defects in this workstations declined Rp. 205,042,-[2].

Researchers interested in conducting research by applying the method of Six Sigma-DMAIC production process in a t-shirt to increase the productivity of the company. Convection Gareng t-shirt founded in 2002 which is managed by Mr. Suryat Mai Andarto. Here provides many gift shop Jogja shirt or t-shirt that is often called Jogja or the conical Asian hat and the banjo. With the presence of Gareng t-shirts are expected to give satisfaction for the tourists who come to Yogyakarta to find gift shop shirt of Jogja. In addition, the price offered less expensive compared to the price of t-shirts other brands. As happens with most of the convection that is mainly in the production process, the problems faced by Convection Gareng t-shirt is the value of a product defect that results in repetition in the production process and has not been He knows the cause factors of disability products.

A move made in this research is to approach Six Sigma-DMAIC. The use of such methods aims to reduce disability, improve the quality of the production process and know the causes of disability.

The objectives to be achieved in this research is to know the level of sigma and can give the proposed improvements with the aim of reducing the number of product defects that occur during the production process of the t-shirt. The benefits of this research for the company is a consideration in the quality control of the product.

2. Literature Review

2.1. Quality

Quality is everything that meets the desires or satisfies customer's needs[3]. Therefore customer satisfaction is the main goal in industry and business.

Quality control is the process used to ensure quality level in a product or service. In the event, we can measure the characteristics of product quality and then compare it with the specifications or requirements and take action accordingly.

In the book, Juran's Quality Handbook explained that quality improvement is an improvement process which is done based on the results of the evaluation[4].

2.2. Six Sigma

Six Sigma is a disciplined process that helps us in developing and delivering products approaching the perfect[5]. Six Sigma also called as comprehensive systems, namely strategic systems, disciplines, and tools which used to reach and to support business successfully. Six Sigma is a quantity (metric) that can use the tools and statistical techniques to reduce defects less than 3.4 DPMO (Defects per Million Opportunities) or 99.99966 percent focused on achieving customer satisfaction[4]. Six Sigma is a comprehensive approach to resolve the problem and process of improvement through the DMAIC phase. DMAIC is an acronym of Define, Measure, Analyze, Improve, and Control. The acronym DMAIC has to mean from word to word that is: first, Define has the meaning as the problems of quality in the production process as well as to seek the greatest contribution that caused by disability or poor product. Second, Measure is a measurement which has the important role in the advance of the greatest quality control. Third, Analyze is as the stages to analyze the data and to find out the causes of the failure process and determine how to reduce product defects. Fourth, Improve is used to make plans that are corrective action and quality improvement. It used to eliminate causes of the roots and to prevent the causes of it repeat itself, so it can create a new operating procedure. Last, Control is the final stage which done to control in every activity so it gets good results.

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Table 1. Number of defect per million

Probability without Defect	Defect Per Million Opportunities (DPMO)	Level Sigma
30,9	690000	1
69,2	308000	2
93,3	66800	3
99,4	6210	4
99,98	320	5
99,9997	3,4	6

2.3. Quality Tools

A good SIPOC (Supplier, Input, Process, Output, Customer) diagram is showing a complex workflow into the simple visualization and easily to understand by people who have interested in work process or make improvisation into the work process.

Cause-Effect Diagram is a graphical overview that displays data about the factors causing a failure and the inconsistency which used to analyze the sub factors of the emergence problems.

Pareto diagrams can identify the most important issues that affect to the quality improvement efforts and provide guidance in allocating limited resources to solve the problem[6].

FMEA has tables shaped and serves to identify the impact of failures of process or design, it gives the analysis regarding the priorities of the response by using the parameter values of the Risk Priority Number (RPN), identifies potential failure modes, as well as minimizing the chances of failure later[8]. The number of RPN is the result of the multiplication between the rank bad influence (severity), the rank of possibility (likelihood), and the rank the effectiveness.

$$\text{Severity} \times \text{Likelihood} \times \text{Effectiveness} = \text{RPN} \quad (1)$$

2.4. Map Control

According to Tannady (2015), the making of the map control is affected by the type of observation data. The data type is divided into 2 types: variable data and attribute data. Each of data types has a kind of map to control itself. While the constituent component of the control consists of maps that are:

a. Control of boundary line (Upper Control Limit), it is Control over the boundary line for a diversion that can be tolerated.
b. Central Line or midline (Central Line), it is the line that symbolizes as the absence of deviations from the characteristics of the sample.
c. Lower control limit line (Lower Control Limit), it is the lower control limit line for a deviation from the characteristics of a sample[7].

Data attribute has the discrete data type and the data obtained as a result of the calculation. An example is to calculate the number of defects or the proportion of defective products[5]. In this study, a map control data attributes are used i.e. map control. Map controls used if you want to monitor the proportion of items that have certain characteristics. The map control is typically used to describe the proportion of the products or transactions that are not eligible[8]. The following is the formula for finding the values of CL, UCL, $dan\ LCL$ on a map control.

$$p = \frac{x}{n} \quad (2)$$

$$\overline{P} = \frac{\sum_{i=1}^{g} P_i}{g} = \frac{\sum_{i=1}^{g} X_i}{n.g} \quad (3)$$

$$CL = \overline{P} \quad (4)$$

$$UCL = \overline{P} + 3S_P \quad (5)$$

$$LCL = \overline{P} - 3S_P \quad (6)$$

where

$$S_P = \sqrt{\overline{P}(1-\overline{P})/n} \quad (7)$$

description

p = proportion of mistake in each sample.
n = the number of samples taken in the inspection.
x = the number of the wrong product in each sample.
P_i = the proportion of errors per sample or subgroups within each observation.
g = a large number of observations are carried out.
$\overline{P}$ = line Center map controlling the proportion of errors.

3. Result and Result Analysis

3.1. Data Collection

Data collection which is a process of collecting the necessary data at the time of research. The required data on this research is data demand for t-shirts, the flow of the process of making t-shirts, as well as a number of the defective product from a t-shirt.

3.2. Data Processing

3.2.1. Define Phase. SIPOC diagram is a way to find out the flow of the production process in producing a product. SIPOC 5 main components in the system of quality, i.e. Supplier-Input-Process-Output-Customer or a process of raw materials that go into products that can be accepted by the consumer. CTQ is used to identify the specific needs of the consumer. CTQ elements can be defined as the process of the influential directly towards the achievement of the desired quality. It needs to identify the types of defects in products of the t-shirt. Based on the results of the research there were several problems which affected in defects that appear. It can be seen in **Figure 2** which is a description of the defect at the process t-shirt production.

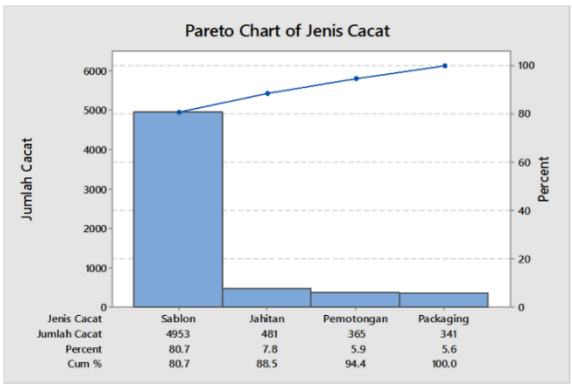

Figure 2. Description of detective t-shirt products

3.2.2. Measure Phase. At this stage, there are 4 types of disability which inspected i.e. screen printing, stitching, cutting, and packaging. For example to calculate map in the subgroup 1 i.e. as follows (after 2nd revised):

total disability = 4,536
total inspections = 574,337
total inspection subgroup 1 = 22,293
total disability subgroup 1 = 214
then the proportion of disability on subgroup 1 is

$$p = \frac{\text{Number of defect}}{\text{Number of samples}} \quad (8)$$
$$= \frac{214}{22,293}$$
$$= 0.009599$$

the average proportion of disability was

$$\bar{p} = \frac{\text{Total number of defect}}{\text{Total number of samples}} \quad (9)$$
$$= \frac{4,536}{574,337}$$
$$= 0.007898$$

the upper control limit calculation (UCL) and the lower control limit (LCL) is as follows: calculation of upper control limit (UCL)

$$\text{UCL} = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \quad (10)$$
$$= 0.007898 + 3\sqrt{\frac{0.007898(1-0.007898)}{22,293}}$$
$$= 0.009676$$

calculation of the lower control limit (LCL)

$$\text{LCL} = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \quad (11)$$
$$= 0.007898 - 3\sqrt{\frac{0.007898(1-0.007898)}{22,293}}$$
$$= 0.006119.$$

With regard to the map control disability products t-shirt during the last 3 years i.e. from January to December of the year 2014 the year 2016 can be seen in **Figure 3**:

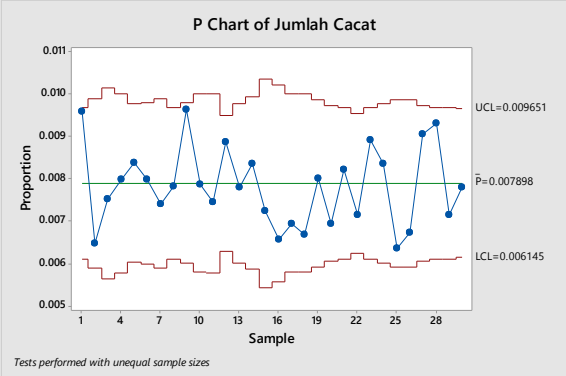

Figure 3. Map of disability control after the second revised

Based on the map control in **Figure 3** indicates that the process was already in conditions in statistics control so that it can proceed to calculate the DPMO (Defects Per Million Opportunities) and the value of sigma. The results from these observations obtained DPMO calculation of 1,975 and sigma value of 3.10. This can be interpreted that there is a possibility of 1,975 disability per million production chance t-shirt. Can be seen in **Table 1** below.

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Table 3.1. Calculation of the limit of control map

Step	The activity	Equation	The Results Of Calculations
1	Process quality is known to want what?	-	The result of the production of t-shirts
2	How many produced t-shirt?	-	574337
3	How many produced a t-shirt that can meet the standard?	-	569801
4	Calculate the result to the process defined in step 1	= (step 3)/(step 2)	0.9921
5	Calculate levels of defects (errors) are based on the step 4	= 1-(step 4)	0.0079
6	Specify the number of potential CTQ that can lead to disability	= the number the characteristics of the CTQ	4
7	Calculate the rate of defects (errors) per characteristics CTQ	= (step 5)/(6 steps)	0.001975
8	Calculate defects per one million opportunities (DPMO)	= (step 7) x 1 million	1975
9	Convert DPMO (step 8) into the value of sigma	-	Between the 4.38-4,39
10	Make inferences	-	Sigma level was 4.38

How to calculate a linear interpolation in the determination of the value of the sigma level can use the conversion table level sigma. As for the value of the DPMO amounted to 1,975 located between 1,926 DPMO (4.39 sigma), and 1,988 DPMO (4.38 sigma). Using linear interpolation then obtained the following results:

$$Y = \frac{(Y_2 - Y_1)}{(X_2 - X_1)}(X - X_1) + Y_1 \quad (12)$$

$$= \frac{(4{,}39 - 4{,}38)}{(1.926 - 1.988)}(1975 - 1988) + 4{,}38$$
$$= \frac{(0{,}01)}{(-62)}(-13) + 4{,}38$$
$$= 4{,}382097 \approx 4{,}38$$

So the sigma level in the period 2014-2016 there at level 4.38 sigma. With the results of 1,975 DPMO value then it shows that for every 1 million times the production possibility of disability is 1,975.

3.2.3. Analyze Phase. The Cause and Effect diagram shows the specific problem. Based on observations which were done by the researcher, there are factors that become caused by t-shirt defects on the process of t-shirts production. Those factors have related to humans, machines, methods, materials, media, and motivation that depicted visually with the fishbone diagram (Fishbone diagram). It can be seen in **Figure 4**.

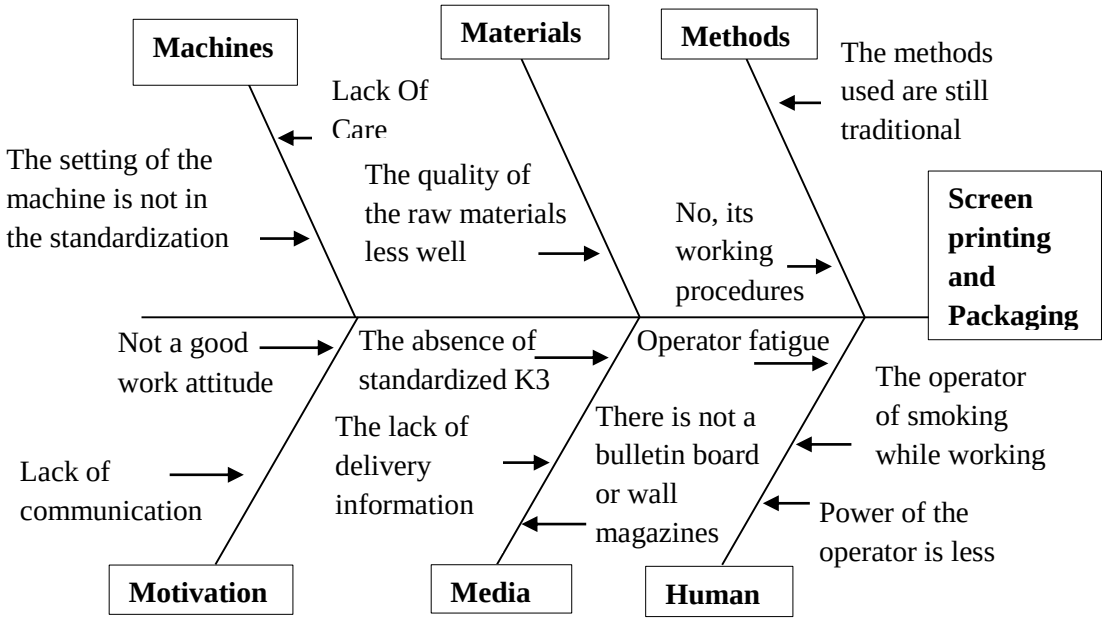

Figure 4. Cause and effect diagram of the attributes of screen printing and packaging

To identify the sources and the root of the problem, FMEA is using Risk Priority Number (RPN) from each of the defects that have occurred. Disabilities who have the highest RPN would become the main focus of the improvements that will be made. How to put priority corrective actions can be done through a list of values with FMEA RPN and it can be seen in **Table 2.**

Table 2. Failure mode and effect analysis (FMEA)

No.	Description Of The Process	Mode The failure of the	The Potential Effects Of Failure	S	The cause of the Potential The failure	O	Process Control the time This	D	RPN
1.	Screen printing	Picture Slanted	Imperfect screen printing results	8	• The Operator is not thorough • Operator fatigue	9	• The manufacture of standard operational procedures • Review about the workload	8	596

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Table 2. Failure mode and effect analysis (FMEA)

No.	Description Of The Process	Mode The failure of the	The Potential Effects Of Failure	S	The cause of the Potential The failure	O	Process Control the time This	D	RPN
2.	Stitches	The outer and inner side seam untidy	Stitches t-shirt untidy (seam threads do not follow) and stitching is not strong	7	Tailoring errors on a t-shirt that is caused by decreased consistency work and sewing machines that are having trouble	5	Examination on any part t-shirt before being sewn and sewing machine checks if having problems	6	210
3.	Cutting	Fabric doesn't match	Fabric defects cannot be manufactured with sizes that don't follow standards	5	• Raw material used is sometimes hollow • Cut machines & Scissors blunt because the use of high-intensity causing quick blunt	8	Surveillance against the incoming fabric raw material as well as checks on tools (cut machines & scissors) checked first if experienced blun	7	280
4.	Packaging	Delay in production	Swelling production costs	8	• Machine press is not hot • Glue plastic adhesive strong	8	• Periodic inspection of the press machine • Standar-dization of plastic raw materials	8	512

Based on the results obtained from the RPN then the improvement is focused on the process of screen printing and packaging. It can be seen in Table 2 below.

a. Rank 1, 596 RPN. Picture tilted due to imperfect screen printing results caused the operators not thorough and fatigue. Therefore, to do a review on the workload and the procurement of standard operational procedures
b. Rank 2, 512 RPN. The delay in production may result in operating expenses caused by a machine press which is not hot and the plastic glues are not strong. Hence it should be holding

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of standardization regarding plastic raw materials and monitoring done on the process and the time of packaging.

3.2.4. Improve Phase. This stage is the fourth stage in the improvement of the quality of six sigma. At this stage will be given a solution for a problem that occurs, that can be seen in **Table 3** below.

Table 3. The proposed improvements to the production process against both t-shirt

No.	Description Of The Process	The cause of the failure	Proposals for improvements
1.	Screen printing	The operator does not meticulous	The company is obliged to make policy by providing job training in order to support the ability of workers in running the operations of production with the standards and specifications determined by the company.
		Operator fatigue	• The company should pay attention to the condition of the operator the operator does not get too exhausted with the work performed and the company must add to the facilities needed by the operator • The company should give attention to workers who do the heavy work and give you extra time to rest for a moment in order to be fit body condition back
2.	Packaging	Machine press not hot	• The company must make the machinery and Procedure Ordinance the use of machines that are good and true • The company makes engine maintenance schedules for workers in accordance with the scheduled time
		Plastic adhesive glue less powerful	In this situation, the special monitoring is required in the receipt of raw materials from major suppliers

3.2.5. Control Phase. This stage is the last operational phase in the process of improving the quality of Six Sigma. The result of this stage, i.e. quality improvement that is documented and then disseminated. At this stage of the analysis is done using observation data turns out there is a major problem in the process of production of a t-shirt screen printing process and process i.e. packaging. The production defects occur due to operator fatigue, the power of the operator is less, the method used is still traditional, the absence of employment standards or guidelines on work procedures, lack of delivery information, etc. Efforts are being made to resolve the problem is to create a reference work procedures that are clearly at workstations which are problematic.

4. Conclusions and Suggestions

Factors become a cause of the onset of disability products are the absence of work procedures, the quality of the raw materials that are less good, the skills of the operator, the descent of workers concern, the unstable machine conditions and lack of motivation in work. The value of sigma and sigma 1.5 shift is

achieved at this stage of the company's quality checks with the DPMO 1975 was 3.10 sigma and sigma 4.38.

The company should perform repairs on machines and tools production on a regular basis and schedule maintenance work as well as make hygiene area standard operational procedures in the running of the production process when the incoming raw material to the finished product.

For the development of quality control regarding the next expected to use other methods.

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