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APPLICATION OF LEAN SIX-SIGMA METHOD AND DEMERIT CHART TO MINIMIZE DEFECTIVE PRODUCT

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ABSTRACT

Quality control is a form of inspection using certain techniques or methods in decision-making to get the quality standards that have been determined. One type of quality control is using the method of Lean Six Sigma to identify and eliminate waste in activities that are not worth the added value through a continuous increase to reach the level of Six Sigma, then use the demerit control chart as a monitor of the production process. The purpose of the study was to find out how to minimize defects in the 220ml Aqua cup mineral water packaging with the method of Lean Six Sigma and Demerit control chart. With the analysis that has been done, it is known that in the 220ml Aqua Cup product the DPMO value for defects in the 220ml AQUA Cup production process is 22912.83, which is the level of sigma is 3.43 and the process capabilities value is 0.77087 which mean that it still needs a process control for minimizing the product defects.

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1. INTRODUCTION

The development of science, technology and the influence of globalization results in major changes in the business sector, both manufacturing or service industries. The era of free markets do not restrict trade between countries, which led to every product from other countries can spread freely in Indonesia. So, quality control on a product is needed, so that consumer desires can be fulfilled and the company can remain and be able to compete with other similar companies.

Quality is an effort of producers to fulfill customer satisfaction by providing what is a necessity, expectations, and even expectations of customers, where the effort is visible and measurable from the final results of the products produced (Hendy Tanady, 2013). In other words, quality is a guarantee that must be given and must be fulfilled by the company to consumers. The companies engaged in the production of an object must pay more attention to quality control activities, especially for companies engaged in the mineral water industry.

Efforts in controlling quality are considered from taking water from springs to the production process and packaging. Efforts in controlling quality are considered from taking water from springs to the production process and packaging. Companies that produce mineral water are expected to be able to apply the Lean Six Sigma method to observe the production process directly. So, that sigma standards can be controlled and the production target is embraces. The method is one of the many methods to monitor the production process and identify waste (defects) in the production process. Lean is a systemic and systematic approach to identifying and

eliminating waste or activities that are not worth the added value. The waste in question consisted of seven types of waste, namely overproduction, waiting, transportation, overprocessing inventory, motion and defect (Gasperz, 2007).

Six Sigma is an approach to solving problems and improved processes through the DMAIC stages (define, measure, analyze, improve, and control). Lean Six Sigma is a combination of Lean and Six Sigma which is a systemic and systematic approach to identifying and eliminating waste or activities - activities that are not worth the added increase through continuous improvement to achieve six sigma performance levels, by producing aqua 220 ml mineral water products to pursue excellence and perfection in the form of only producing products with 3.4 defects for every one million oppurtunities.

2. RESEARCH METHODE

2.1 Lean

Lean is a process improvement, which is useful for safety repairs, quality, speed, and costs by elimination against Waste (Mann, 2010). The purpose of the Lean concept is to eliminate waste such as time, effort, material, make products according to customer requirements, and reduce costs when making improvements (George, 2002).

2.1.1 Lean Improvement Tools

According to George (2002), there are several tools that can be used in Lean Improvement, as follow:

- Value stream mapping (VSM)
- Pull system
- Setup reduction

2.1.2 Activity Classification

According to Daneshgari & Wilson (2008) all acrivities in the company can be classified into three categories, namely:

- Value added activity
- Value added but necessary activity
- Non value added activity

2.1.3 Waste

Here are the types of waste that exist in the production process, namely Transportation, Inventories, Motion / Movement, Waiting, Over Process, Over Production, Defective Product, Employee Creativity that is not developed

2.2 Six Sigma

Six Sigma is a method that used to improve quality and reduce the cost of poor quality. In the implementation of Six Sigma has 2 submetodes, namely, the DMAIC method and DMADV method. The DMAIC method (Define, Measure, Analyze, Improve, Control) is a method that aims to improve existing processes that already exist and find a way to make improvements. While the DMADV method (Define, Measure, Analyze, Design, Verify) is a system that aims to create a new process by all means to produce a performance without errors, or zero deffect. This method is used for a new product or process (Gasperz, 2010).

2.2.1 Define

Define is the first step for identify products or processes that will be corrected in determining The sources needed in project implementation. Things to do in the process is to make the diagram SIPOC (Supplier, Inputs, Process, Outputs, Customer) and then identify Critical to Quality.

2.2.2 Measure

In this step, the first thing to do is create control charts to monitoring the production process. The next thing to do is calculate the DPMO value and Sigma level to find out the performance of production performance.

DPMO calculation formula:

$$\text{DPMO} = \frac{jumlah\ cacat}{unit\ yang\ diproduksi \times CTQ} \times 1.000.000 \qquad (2.1)$$

The next thing to do is to convert the value of DPMO to sigma level using the formula in Excel, namely: *Normsinv*(1.000.000-DPMO/1.000.000) + 1.5.

Last thing to do at this step is calculate the value of the process capability index, with the formula:

$$Cp = 1 - \bar{p} \qquad (2.2)$$

2.2.3 Analyze

In this step, several things are carried out, including determining the priority of repairs, identifying the sources and root causes of failure from a process using fishbone diagram.

2.2.4 Improve

Provide a proposed repair or rencaa action that can be done after knowing the source and root of the problem of the problems.

2.2.5 Control

2.3 Lean Six Sigma

Lean Six Sigma is a combination of Lean and Six Sigma which can be defined as a business philosophy, a systemic and coccupatory approach to identify and eliminate waste or activities that are not worth the added continuous radical increase to reach the level of six sigma to pursue excellence and perfection in the form of only producing 3.4 defective products for every million opportunities

2.4 Demerit Chart

In the quality control process, various types of defects are determined by the company could have occurred in the product. This type of disability is not everything important, some can be tolerated and some cannot be tolerated at all. This condition requires the classification of defects based on its weight using the Demerit control map method (Montgomery, 2005). The pattern of product defects are generally based on the weight of disability according to Grant and Leavenworth (1988) depending on the seriousness of different disability classification as follows:

a) Class A defects (Critical)

The unit will cause an accident that is not easy to repair so that it is not suitable at all to offer.

b) Class B defects (Major)

The unit will increase maintenance costs and can experience class A operational defects so as to reduce product life.

c) Class C defects (minor)

The value is described as the center line in the demerit control diagram. Meanwhile, the value of the control limit can be described as UCL (upper control limit) and LCL (bottom control limit).

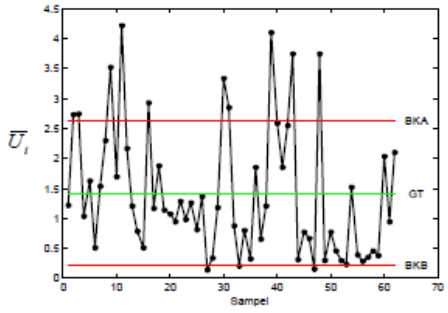
$$\text{UCL} = \bar{u} + 3\sigma, \tag{2.3}$$

$$\text{CL} = \bar{u}, \text{ dan} \tag{2.4}$$

$$\text{LCL} = \bar{u} - 3\sigma \tag{2.5}$$

With value $\hat{\sigma}_u$ is deviation standart:

$$\hat{\sigma}_u = \sqrt{\frac{w^2{}_A\bar{u}_A + w^2{}_B\bar{u}_B + w^2{}_C\bar{u}_C}{n}} \tag{2.6}$$



2.5 Research Procedure

1. Collecting theories to be used in analysis
2. Collecting data from related companies

The collected data is the data of production process and the data of defective product

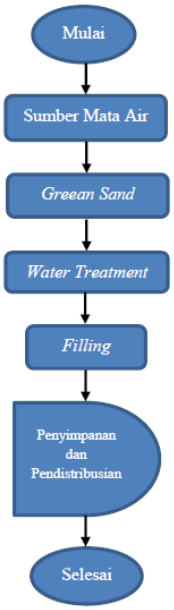
3. Identify and data processing

Which is brainstorming production process, identification of waste, make the flow chart, calculate the DPMO value, analysis of capabilities, making histogram, because of the effect diagram.

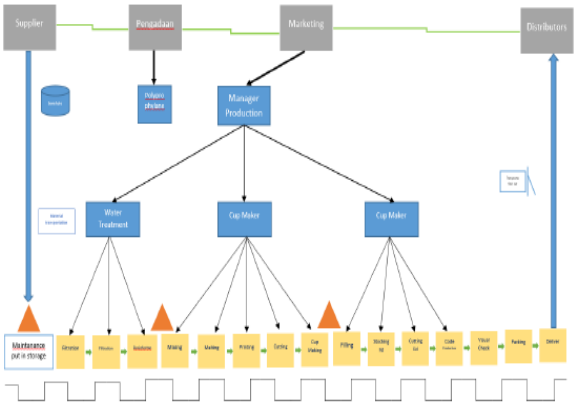
4. Conduct further analysis related to the root of the problem and provide repair recommendations
5. Conclusion

3. RESULT AND ANALYSIS

3.1 Brainstorming production process with flow chart and value stream mapping



Gambar 3.1.1 Flowchart of Aqua 220ml productioning



Gambar 3.1.2 VSM of Aqua 220ml productioning

3.2 Identification of waste

No	Jenis Waste	Operator			Rata-rata
		1	2	3	
1	*Over Production*	0	0	0	0
2	*Delays (Waiting Time)*	0	0	0	0
3	*Excess Transportation*	0	0	0	0
4	*Inappropriate Processing*	0	0	0	0
5	*Unnecessary Inventory*	0	0	0	0
6	*Unnecessary Motion*	1	1	1	1
7	*Defective Product*	2	2	2	2

Gambar 3.2 type of waste

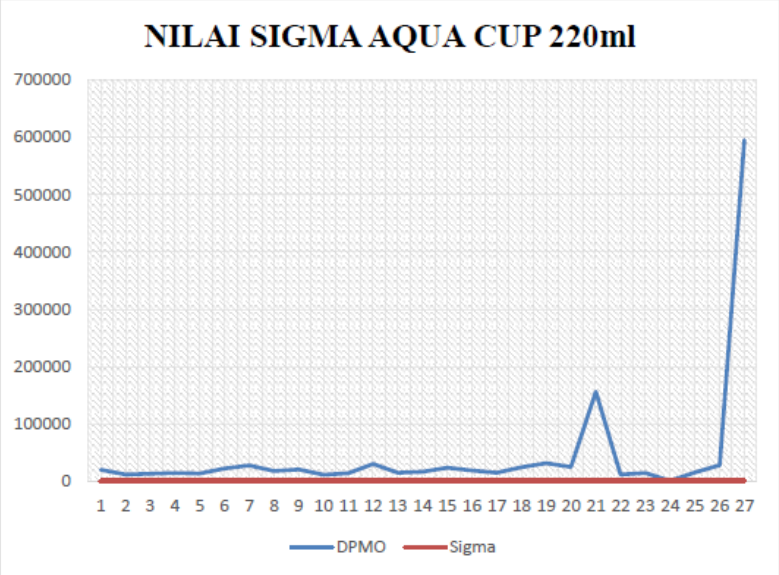
Results are shown in image 3.2 show that the types of waste most frequently happen is defective product or a defective product with an average value of 2 means very frequent activity of defective products in one shift work. The other type of waste is unnecessary motion or activities that are less important with an average value of 1 means that the activity often occurs in one work shift.

3.3 DPMO Value

DPMO is a measure of the failure the Six Sigma that can indicate failure per million possibilities. The purpose of the DPMO is to measure the level of Six Sigma which is caused by the defect. The following are steps to calculate the Top Value (Total Opportunities), DPO (Defect per Million), DPMO (Defect per Million Opportunities) and Sigma values on the table and sigma level on the 220 ml AQUA mineral water products.

Conversion of DPMO calculation results with Six Sigma table

No.	Jumlah Produksi	Jumlah *Defect*	CTQ	DPU	TOP	DPO	DPMO	*Sigma*
1	8104	1575	10	0.19435	81040	0.01943	19434.85	3.57
2	9600	1078	10	0.11229	96000	0.01123	11229.17	3.78
3	9744	1203	10	0.12346	97440	0.01235	12346.06	3.75
4	13608	1858	10	0.13654	136080	0.01365	13653.73	3.71
5	9058	1175	10	0.12972	90580	0.01297	12971.96	3.73
6	7214	1547	10	0.21444	72140	0.02144	21444.41	3.52
7	9096	2458	10	0.27023	90960	0.02702	27022.87	3.43
8	9456	1642	10	0.17365	94560	0.01736	17364.64	3.61
9	9648	1928	10	0.19983	96480	0.01998	19983.42	3.55
10	13608	1455	10	0.10692	136080	0.01069	10692.24	3.80
11	9072	1200	10	0.13228	90720	0.01323	13227.51	3.72
12	4824	1429	10	0.29623	48240	0.02962	29622.72	3.39
13	9744	1379	10	0.14152	97440	0.01415	14152.3	3.69
14	9528	1516	10	0.15911	95280	0.01591	15911	3.65
15	9648	2210	10	0.22906	96480	0.02291	22906.3	3.50
16	13248	2408	10	0.18176	132480	0.01818	18176.33	3.59
17	9075	1298	10	0.14303	90750	0.01430	14303.03	3.69
18	4533	1076	10	0.23737	45330	0.02374	23737.04	3.48
19	9384	2903	10	0.30936	93840	0.03094	30935.64	3.37
20	14544	3544	10	0.24367	145440	0.02437	24367.44	3.47
21	1472	2291	10	1.55639	14720	0.15564	155638.6	2.51
22	13608	1488	10	0.10935	136080	0.01093	10934.74	3.79
23	9114	1248	10	0.13693	91140	0.01369	13693.22	3.71
24	0	0	10	0	0	0	0	0
25	9582	1403	10	0.14642	95820	0.01464	14642.04	3.68
26	4824	1319	10	0.27342	48240	0.02734	27342.45	3.42
Total	231336	42631		5.95734	Rata-rata		22912.83	3.43



Graph of Sigma Aqua Value 220ml Cup Packaging

Data was obtained from the results of the observation during September 2020 which contained data on defects and the number of defects in the section. The results of the calculation of DPMO values used to determine the comparison of defects per one million opportunities. From the calculation results obtained the average DPMO value of 22912.83 and Sigma value of 3.43. The average value of the DPMO can be interpreted that there is a possibility of 22912.83 disability that will occur in one million drinking water in the 220 ml AQUA cup packaged. Whereas if it is converted to the value of Sigma, then the value that is deployed is 3.43 which indicates that it is still too far from the value of 6 Sigma, although it is seen from the value of the sigma the production process of drinking water in 220ml cup packaging at PT Tirta Investama Langkat is quite good. This is because because the value of sigma the average industry in Indonesia is around 2-3 sigma. However, because it has not reached Zero Defect where it can reduce the waste of materials and power that arises due to the reject, the production process must increase the value of the sigma so that the amount of product disability can be pressed.

3.4 Analysis of Capabilities

seen

$$Cp = 1 - \bar{p}$$

$$Cp = 1 - \frac{5{,}95734}{26}$$

to

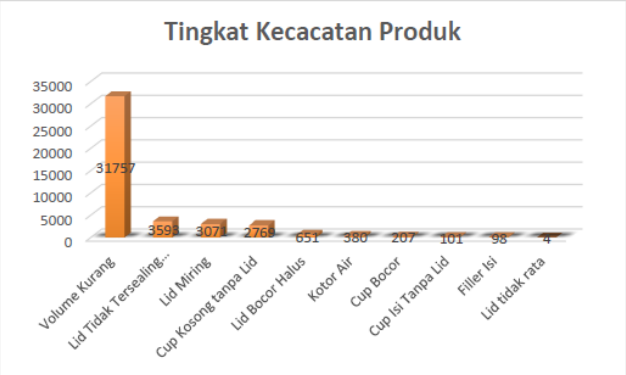
$$Cp = 1 - 0{,}22913$$

$$Cp = 0{,}77087$$

From the calculation of the capability level which is worth CP = 0.77087 It can be that the process capability has not been centered on the target. Score CP <1.00 shows that the capability in the process is still very low, So it needs to be increased through improvement in the process. This matter means that it still needs efforts improve quality production to have a very small failure rate towards zero (zero defct oriented).

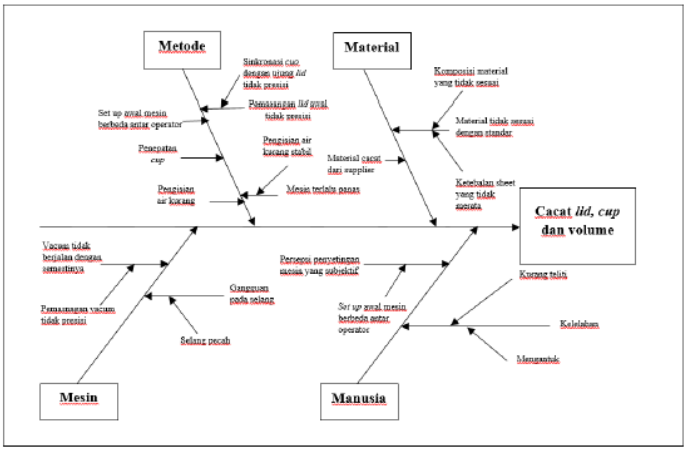
3.5 Histogram

This histogram is used as a ranking or order to find out the type of defect that is the most dominant or often occurs to the rare.



3.6 Fishbone Diagram

Fishbone diagram is used to search for factors that cause the occurrence of defects in a production process, subsequent to the analysis.



3.7 Analysis Result and General Discussion

The quality control process implemented is by checking incoming material that has been referred by the QPA (quality plan agreement) to the supplier. The method used is the MIL-STD sampling technique, which is a method to determine the acceptance or rejection of lots (in this case 1 lot = 1 bottle of bottled drinking water which contains 48 pieces) to be observed, if PASS (passes), the material will be used in production, and otherwise the material is rejected. During production, the production team checks visually (visual checking), if there are products that are out of standing (outside the criteria) then the product will be returned to the warehouse. Then by looking at the histogram shown in histogram, it is known that the most dominant level of defects that occurred in September 2020 was the type of low volume defect. Insufficient volume is a condition where the volume of water filled in the cup does not match the standard / less and can also occur because the product water filled in the cup is spilled. This can happen because the filter on the filling unit has been dirty by the O3 ozone lender. Meanwhile, the product water that was filled in the cup spilled due to the rocking holder caused by the counter bolt not being tight and the indexer bearing on the machine worn out. Based on this situation, suggestions that can be made to reduce or minimize product defects that occur are to calibrate the tool. According to interviews conducted with Quality Control at PT Tirta Investama Langkat, instrument calibration can be carried out after

400 hours of use. And for other sources of disability, it can be caused by several factors, including: machine, material, human and method factors. An several suggestions for improvement were obtained, such as providing training for workers to carry out SOPs properly, carrying out better quality control in conducting material inspections, installing blowers to stabilize room temperature which affects the machine as well, as well as conducting field inspections regularly more routine to monitor the course of production. If the quality control applied is good, then the goal is to achieve the 6-sigma level, which is only 3.4 defects out of one million possibilities. it will be easier.

4. CONCLUSION

From the results of the analysis of calculations and discussions that have been done, the conclusions that can be drawn in this study are:

1. The value of Defect Per Million Opportunity (DPMO) for defects in the production process of Aqua Cup 220ml is 22912.83 means that in one million opportunities there will be 22913 units of possible products will have defects in the production process of Aqua Cup 220ml. As for the sigma level is 3.43 and the value of process capability is 0.77087 which indicates that there is still a need for good process control to minimize product defects.
2. In the 220 ml cup mineral water product, there are 10 types of defects, namely uneven lid, empty cup without lid, tilted lid, dirty water, low volume, smooth leaking lid, lid not sealing perfectly, leaking cup, filler filling and filling cup without member. Factors that cause deviations or defects in the product are the negligence of the operator, the occurrence of errors in the machine and methods used in production.

3.

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