Quality Control Analysis of Defective Products on Prism Sheets Using Lean Six Sigma with the DMAIC Concept

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ABSTRACT

One method to improve quality is Lean Six Sigma with the concept of DMAIC (Define, Measure, Analyze, Improve and Control). It is oriented that there will only be 3.7 product defects from every 1 million products produced. This research aims to improve the quality of prism sheet products at PT XYZ, especially prism sheets that often have product defects. The results showed that there were 6 (six) types of product defects in prism sheets during the November 2024 period. Among them: Dirty, White Spote, Scratches, Crease, Ripped, Double Cut, From the calculation results, the average sigma level is 5,06 with an average DPMO value of 1030, Based on the pareto diagram, improvements are prioritized on the 2 (Two) most dominant types of defects. Namely the type of Dirty with a defect percentage of 90.05%, White Spote 5.69% Then a cause and effect analysis using fishbone is carried out, it is known that human factors, materials, machines, the environment and methods are factors causing two types of defects. In the improvement stage, improvement proposals are made using the 5W + 1H method as a form of improvement in quality improvement.

Keywords: - 5W+1H, Lean Six Sigma, DMAIC

INTRODUCTION

PT XYZ is a company that produces prism sheets in four sizes: 24 inches, 32 inches, 43 inches, and 55 inches. The production system used by PT XYZ is a make to stock (MTS) system, which means production is carried out according to requests from consumers. And currently receiving orders from loyal customers. PT XYZ as a manufacturing company is very concerned about the quality of its products. Good product quality can increase consumer confidence and make the relationship of cooperation will continue. The increasingly advanced development of globalization has led to increasingly fierce competition between businesses.

Companies try their best to attract consumers to buy. High-quality products are one example of good performance. Consumers usually believe that better quality products are worth the price. However, if the purchased product has poor quality, consumers will be disappointed and may not buy the same product again. As a result, the company must immediately improve the quality.

The production process of making prism sheets goes through 3 processes, namely cutting, clean machine, visual checking. Based on the quality inspection that has been carried out, the produced prism sheets have several types of defects. In the cutting process, clean machine, the types of defects that occur include Dirty, scratches, crease, ripped, double cut, white spote. These types of defects result in the occurrence of defective products. The number of defective products that occur in prism sheets.

Many defective products can increase production costs and time. This can cost the company in terms of time, cost, and resources. Consumers may lose confidence in defective products that have passed inspection and are accepted. Therefore, to avoid defective products, quality improvement is required.

Theoretical Foundation

Defective products can be reduced if the company is able to reduce the number of defects that occur in the product. With the decrease in the number of defects, it is expected that the number of defective products will

also decrease. Thus, the Six Sigma DMAIC method can be used which aims to minimize defects and maximize the added value of a product. [1] In addition

Krisnaningsih and Fadli Hadi: Based on the results of the identification of the source of occurrence of defects that occur due to human factors, methods, materials and tools. From the calculation of the sigma level and DPMO, the average result of the sigma level is 3.92 with a DPMO value of 13166.43. Based on the Pareto Diagram, improvements are focused on 3 types of defects that occur with a percentage of problems that must be resolved 80% according to Pareto's law, namely Sagging with a percentage of (38.16%), Orange Peel with a percentage of (25.65%) and Low DFT with a percentage of (19.06%). The three defects are analyzed using Fishbone Diagram to describe the cause of the defect. At the Improve stage, improvement proposals are made using the 5W+1H method as follows method for company consideration in implementing better quality with the help of statistical tools to facilitate the control stage. It is hoped that the company can implement Six Sigma with the DMAIC (Define, Measure, Analyze, Improve and Control) stage in the future to improve quality with the hope that zero defects will be beneficial to the company's ideal conditions.[2]

Research conducted by Poppy Rahayu and Merita Bernik: Based on calculations, the defect per million opportunity (DPMO) value is 3603.64 and the sigma value is 4.18. At the define stage, a pareto diagram is used to determine the number and type of defects, the measure stage uses a control P-chart to determine product defects that are still within the required limits, the analyze stage uses a fishbone diagram to determine the factors that cause defects, the use of process decision program charts for mapping proposed improvements at the improve stage, the control stage calculates the sigma value of the product and compiles a production process flowchart.[3]

Research conducted by Khusnun Nabila and Rochmoeljati: So that the average DPMO is 17,531.93 with a sigma value of 3.61. From the DPMO results and the sigma value, it can be seen that there are five types of factors that affect defects, namely the man, milleu, machine, method and materials factors. Based on the problems in each factor, continuous improvement is carried out with the Kaizen Five Mchecklist method and the Five Step Plan or 5S (Seiri, Seiton, Seiso, Seiketsu and Shitsuke) which are used as recommendations for improvement to solve the five factors that cause defects.[4]

The large number of defective products that occur due to the absence of awareness from all parties involved so that it can cause the absence of consistency in quality control by reducing the level of the number of defective products per production. In this study, the 5S method is used to achieve and improve product quality through the implementation of Seiri, Seiton, Seiso, Seiketsu and Shitsuke. This study aims to determine what factors cause defective products at PT. XYZ and the right improvement solution to reduce the number of defective products at PT. XYZ 'using the 5S method through the implementation of DMAIC as a form of structured quality improvement stages.(Samsudin, Dewa Kusuma Wijaya, and Nur Islahudin 2023) Related to DMAIC in 2021, it has been products.[5]

Aplikasi lean six-sigma untuk mengurangi pemborosan di bagian packaging semen.[6] Quality Control Besterfield, D. H., & Byun, J. H. (1998). [7]. [8]. [9]. [10]. [11]. [12]. [13].

Based on the description above, the purpose of this study is to determine the current quality level of base paper by measuring the DPMO and sigma quality levels, finding the source of defects, determining solutions to overcome these defects, and measuring the level of product quality as a result of improvements.

MATERIAL AND METHODS

This research begins by determining the problems that occur at PT XYZ Then, I looked at the literature from several previous research journals. This is useful for finding research references and conducting literature reviews. Furthermore, data collection is carried out through direct interviews with company employees regarding the findings of the problem. Then proceed with data processing using the six sigma method (DMAIC). Starting with the define stage finding defect problems in prism sheet products, the measure stage is followed by the calculation and analysis of defective prism sheet products. Furthermore, the analyze stage is carried out by making a pareto diagram to determine the highest level or percentage of defects in prime sheet products. To

determine the cause of product defects, a fishbone diagram is used to conduct the analysis, the improve stage with the aim of reducing the number of product defects, with the hope of achieving zero defects using the 5W + 1H method. control is a consistency check to achieve quality objectives.

The flow of research conducted is as shown below:

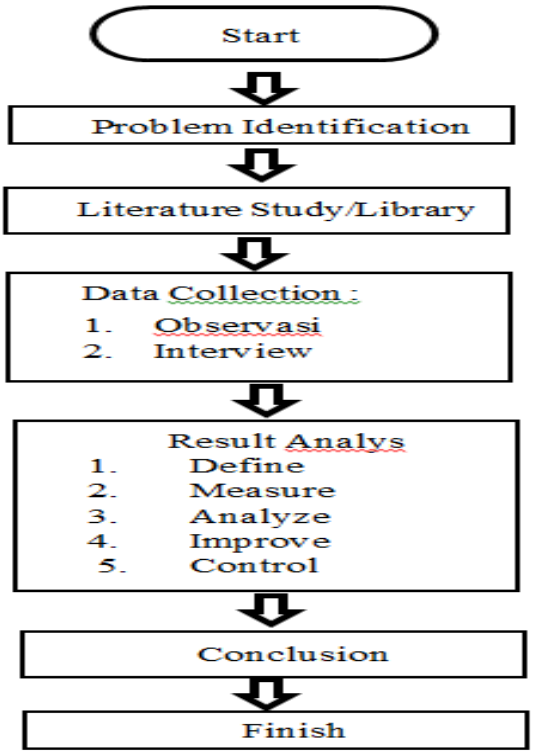

Fig 1. Research flow of Lean Six Sigma Implementation with DMAIC Concept

RESULTS AND DISCUSSION

The production process of prism sheets at PT XYZ can be seen in the chart below:

1. The prism sheet cutting process at PT XYZ uses a mold that is ordered from a supplier and then modified according to the needs and specifications of the mold used in the production of prism sheets at PT XYZ.
2. The cleaning process using a clean machine on prism sheets is carried out to remove dust, oil, stains, or other particles that can affect the quality of the prism.
3. The process of visually checking the prism sheets is an important step to ensure that the prisms are free from defects such as scratches, stains, bubbles, cracks, or other imperfections that can affect their function.

Data processing will be carried out using the lean six sigma method with the DMAIC approach as follows:

Define

Table 1: Types of defects of prism coating products

Type of Defect	Number of Defects (Units)	
Dirty	2850	
Scratches	66	
Crease	35	
Ripped	22	
Double Cut	12	256000
White Spote	180	
Quantity	3165	

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Based on the data that has been collected and analyzed. During the period of November 2024, there were 6 types of defects in the production of prism sheets.

Table 1 states that there are 6 types of defects that occur during the production of prism sheets. Furthermore, the percentage calculation of each type of defect is carried out, such as the example of the calculation of the type of dirty defect below:

$$\frac{Number\ of\ Dirty\ Defects\ (Unit)}{Number\ of\ Defects} = \frac{2850}{3165} x100\% = 90{,}05\%$$

Then calculate the percentage of other types of defects until each percentage value is known, and accumulate the percentage of each type of defect completely. In full, it can be seen in Figure 2 which shows the frequency of each defect against the total defects. As in Figure 2. below:

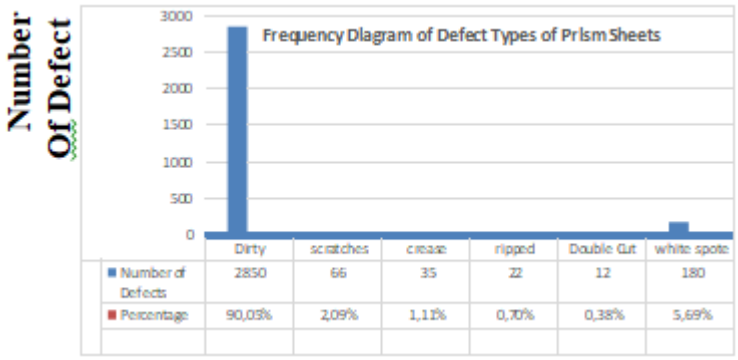

Fig 2. Frequency diagram of defect

Seen in Figure 2. above based on the results of the calculation of the percentage of defective products with the production amount of each defect of prism sheet products.

Measure

The calculation process using the lean six sigma method is as below:

Calculation of Defect/Unit Value (DPU)

$$DPU = \frac{Quantity\ Of\ Defective\ Product}{Production}$$

Example of DPU calculation of Dirty defect type as below:

$$DPU\ Dirty = \frac{2850}{256000} = 0{,}900474$$

Table 2. Defect/Unit calculation Result Value

No	Defect Type	DPU
1	*Dirty*	0,900474
2	*Scratches*	0,020853
3	*Crease*	0,011058
4	*Ripped*	0,006951
5	*Double Cut*	0,003791
6	*White Spote*	0,056872

Then calculate the DPU of other defect types like the Dirty DPU example above. The accumulated defect/unit (DPU) value calculation can be seen in Table 2.

Determine Total Opportunitiest (TOP)

Opportunitiest is the number of opportunities that can cause defects based on the production process Prism lenses have two production process steps, namely cutting and cleaning machine processes so that the TOP formula becomes:

$$TOP = Total\ Prod\ x\ Opportunitiest$$

$$TOP = 256000x2 = 512000$$

Calculation of Defect/Opportunitiest (DPO)

$$DPO = \frac{Defective\ Products\ (D)}{TOP}$$

An example of calculating the type of dirty defect is as below:

$$DPO = \frac{2850}{512000} = 0{,}0055664$$

Next calculate the DPO of all types of defects as calculated above, and the accumulated calculations of all types of defects can be seen in Table 3 below:

Table 3. Defect/Opportunitiest Calculation Result

No	Defect Type	DPO
1	Dirty	0,0055664
2	Scratches	0,0001289
3	Crease	0,0000684
4	Ripped	0,0000430
5	Double Cut	0,0000234
6	White Spote	0,0003516

Calculations Defect/Million Opportunitiest (DPMO)

$$DPMO = DPOx1.000.000$$

Example of DPMO calculation for dirty type defect as below:

$$DPMO = 0{,}0055664\ x\ 1.000.000 = 5566$$

Next calculate the DPMO of all types of defects as calculated above, and the accumulated calculation of all types of defects can be seen in Table 4. below:

Table 4. Calculation Result Defect/Million Opportunities

No	Jenis Cacat	DPMO
1	Dirty	5566
2	Scratches	129
3	Crease	68
4	Ripped	43
5	Double Cut	23
6	White Spote	352

Sigma Level Calculation

$$T.Sigma = Normasinv\left(1 - \frac{DPMO}{1.000.000}\right) + 1{,}5$$

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An example of calculating the sigma defect level of Dirty as belower:

$$T.Sigma = Normsinv\left(1 - \frac{5566}{1.000.000}\right) + 1{,}5$$
$$T.Sigma\ Dirty = 4{,}038502$$

Next calculate the sigma level of all types of defects as calculated above, and the accumulated calculations of all types of defects can be seen in Table 5. below:

Table 5. Sigma Level Calculation Resultsan

No	Defect Type	Sigma Level
1	Dirty	4,038502
2	Scratches	5,154371
3	Crease	5,314302
4	Ripped	5,427208
5	Double Cut	5,570685
6	White Spote	4,888357

Based on the results of the above calculations, it is known that the company is quite good at handling the level of defects. This is based on the sigma value which is close to 6 (in the sense of almost zero defects in the type of defect). However, it can be seen in Table 5. above that product defects still occur. So improvements and quality control must always be carried out so that the company's expectations regarding zero defects can occur.

Analyze

Analysis in the lean six sigma method uses pareto and fishbone diagrams. For the pareto diagram as in Figure 3. Below

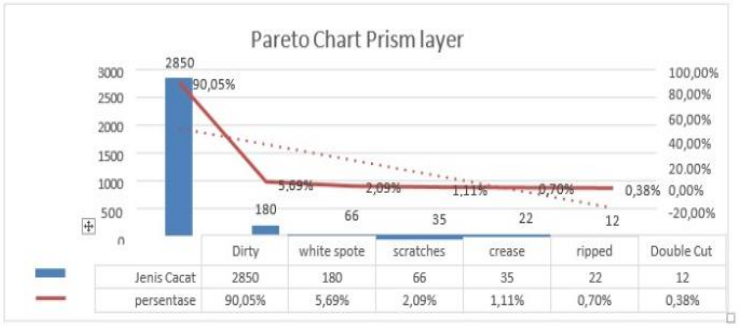

Fig 3. Pareto Chart Prism Sheet

Based on the pareto diagram shown in Figure 3 above, it can be seen that there are 2 types of defects with the highest defect value (dominant). Namely the type of defect Dirty with a defect percentage of 90.05%, White Spote 5.69%. So based on the Pareto diagram, the improvement steps will be prioritized on 2. The most dominant type of defect. Next, we analyzed the cause and effect of the possible occurrence of defects in the two priority defect types using fishbone diagrams. As shown in Figures 4 and 5 below:

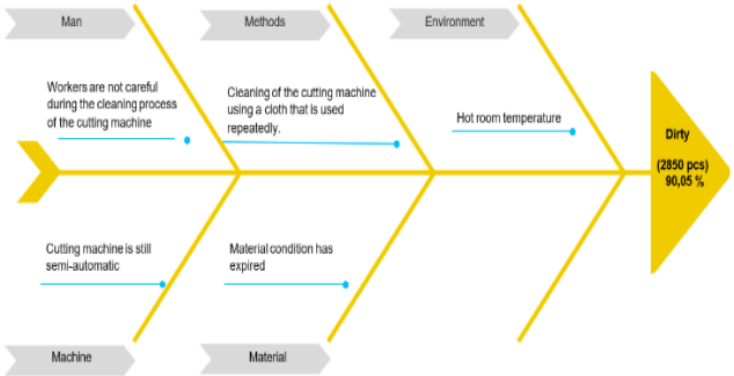

Fig 4. Diagram Fishbone Dirty Defect

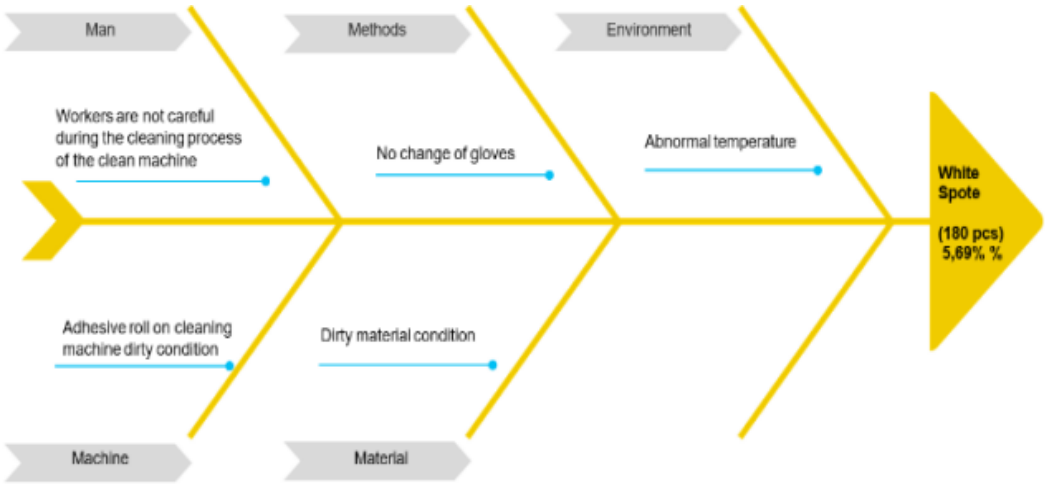

Fig 5. Diagram Fishbone White Spote Defect

Improve

In the improvement stage, the improvement analysis is carried out using the 5W + 1H method, as shown in Table 6 below:

Time Occurred (When)	**Defect**	**Occurrence of Defects (Where)**	**The cause (Why)**		**Person in Charge (Who)**	**Improvements (How)**
	Happened (What)		**Causes**	**Responsible person**		
When ongoing process production	Dirty	Occurs during process Cutting	Man	Workers are not thorough during the cleaning process cleaning cutting machine	Workers of the Cutting process and QC	Workers should ensure that every cutting process according to the SOP and QA should checking periodically
			Machine	Cutting process machine is still semi-automatic	Management	Management should add sensors to the machine to ensure the mold is running properly.
			Methods	When cleaning the cutting machine, the cloth used for the cleaning process is used repeatedly.	Management and QA	We recommend that management and QA make an SOP for the use of duginakan cloth for one-time use.
			Materials	Expired materials	Purchasing, sales and QA department workers	We recommend that before the material enters the production area QC check Raw material regularly
			Environment	Hot room temperature	OHS, Maintenance Department	The maintenance and OHS departments should check the production room air conditioners regularly.

Time Happens (When)	Defect Happens (What)	Happens Defect (Where)	Causes (Why)	Responsible person (Who)	Person in Charge (Who)	Improvements (How)
During the production process	White Spote	Occurred in the clean machine process	Man	Workers are less careful during the clean machine cleaning process	Clean machine and QC process workers	Workers should ensure that every clean machine process is in accordance with the SOP and QC always checks periodically.
			Machine	The blue roll on the clean machine is dirty	Clean machine and QC process workers	Workers should ensure that the blue roll on the clean machine is cleaned
			Methods	Gloves used during work are dirty	Management and QA	Before production, management and QA should make an SOP for the use of gloves for workers so that they change gloves regularly.
			Materials	Material dirty	Process and QC workers	We recommend that workers and QC ensure each material composition is clean or not before carrying out the production process.
			Environment	Temperature Humidity Abnormal	OHS Department	It is better to improve the standardization of room temperature by determining the temperature limit of the air conditioner according to the standard required by the material.

Control

The control stage is explained in the form of input for the company as listed in the 5W + 1H table. So that at least it can help the company in carrying out quality control. After improvements are made, the company still needs to carry out continuous quality control. Such as checking continuous improvement which includes:

a. Conduct regular maintenance of machines and tools for making prism sheets, as a form of preventing defective products.

b. Record defective products every day if any

c. Supervise the raw materials for making prism sheet

This is in line with research [14] which at the control stage emphasizes the documentation stage of the action.

CONCLUSION

From the research results, it is known that there are 6 types of defects from prism coating products including: dirty, whitespote, scratches, crease, ripped, double cut. From the calculation results, the average sigma level is 5.06 with an average DPMO value of 1030. Based on the pareto diagram, improvements are prioritized on the 2 (two) most dominant types of defects. Namely the type of defect Dirty with a defect percentage of 90.05%, White spote 5.69%. Then a cause and effect analysis using fishbone is carried out, it is known that human factors, materials, machines, environment and methods are factors that cause the occurrence of the two types of defects.

Results of the calculation above, it is known that the company is quite good at handling the level of disability. Because the sigma value is close to 6 (in the sense of almost zero defects in the type of defect). In addition, in certain types of defects, the level of disability is still quite high with a low sigma level. Therefore, improvement and quality control must always be carried out so that the company's expectations regarding zero defects can occur. In line with the journal. [15] who said that six sigma is a statistical measurement of only 3.4 defects per million.

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