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Identification of test liner paper production errors through six sigma DMAIC perception

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Abstract

To achieve normal quality, organizations must be able to be aware of and check factors that can affect product quality. Quality control aims to reduce the number of defective or damaged goods, ensure the final results provided comply with company quality guidelines. PT Lohdjinawi Widjaya is a company that produces paper in Indonesia, one of its products is test liner paper. This can be seen from production data for the last 4 days of August with total production of 953,625 kg and total defects of 35,084 kg. From the results of research and data processing using the Six Sigma DMAIC method, it can be concluded that the biggest defect in test liner paper products at PT. Lohdjinawi Widjaya total broken edge defects 18,400 kg or 52%, damaged cross-section 12,406 kg or %. The research results showed that the lowest Six Sigma level results were 3,55 on the fourth day and the highest on the first day was 4,08. Four factors influence product quality including materials, people, methods, and machine.

1. INTRODUCTION

Progress over time has changed the way customers view the products they need. Quality plays an important role in the selection of goods apart from the serious cost factor. To maintain product quality so that creations are within certain limits, efforts must be made to ensure the maintenance of machines, materials, individuals, and techniques (Nurholiq et al., 2019). Good quality from the buyer's perspective, assuming the item purchased meets his or her desires, has benefits that solve the problem commensurate with the effort expended. Quality checks within organizations, both aid organizations and assembly organizations, are essential.

Given the nature of the service or product provided, organizations want to be able to compete in finding and solving customer problems (Putra et al., 2021). If defective goods continue to be ignored it will have a negative impact on the organization. Therefore, factual quality control is very important (Ahmad et al., 2020). To achieve normal quality, organizations must be able to be aware of and check factors that can affect product quality during the production process to avoid disappointment or product defects (Nurdinia et al., 2021). The use of quality control is linked to the quality standards of each company. Quality control aims to reduce the number of defective or damaged goods, ensure the final results provided comply with company quality guidelines, and prevent imperfect goods from reaching customers.

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PT Lohdjinawi Widjaya is a company that produces paper in Indonesia, one of its products is test liner paper. Test liner paper in the manufacturing process experienced problems, namely the large number of defects caused by several factors such as machines, humans, materials, and others. The result of these problems is due to the lack of precise quality control systems implemented by the company. This can be seen from production data for the last 4 days of August with total production of 953,625 kg and total defects of 35,084 kg. Quite a lot of defects that occur are caused by poor company control. Therefore, it is important to complete the exam to find the main problems in developing test liner papers using the Six Sigma DMAIC technique.

In Six Sigma there is a 5-stage DMAIC cycle (Characterize, Measure, Dissect, Improve, Control) which is a continuous improvement process towards Six Sigma targets. DMAIC is carried out deliberately based on information and reality. Quality analysis using the DMAIC method must be carried out sequentially and structured to find out in more detail the factors related to product defects.

2. METHODS

2.1 Types of research

The research used quantitative techniques. This method utilizes a numerical model as the result to be achieved. This method aims to obtain data regarding research objects which can be production processes, production results, and types of production failures.

2.2 Data collection

Information collection is carried out to obtain information that is expected to direct research. Direct observation and interviews with company employees were used to collect data. To collect valuable data for research, two types of information are taken :

a. Primary data in this research is direct observation and interviews with companies to find out the products produced. Collection of important information, for example, organizational profile, production volume, type, and number of imperfections in the production process.
b. Secondary data in this research is literature studies to support the preparation of reports related to what is discussed in this research, both from books, journals, articles, and company data.

2.3 Data analysis

The analysis technique used is the Six Sigma DMAIC method to carry out the product quality control process. The following is an explanation of the Six Sigma DMAIC method carried out at PT. Lohdjinawi Widjaya for the quality control process :

a. Define

The stage of identifying product defect problems is called the define stage. The stages of the definition process are as follows :

1. Identify CTQ (Critical To Quality) on test liner paper products.
2. Identify the type of defect and its percentage in the test liner paper product.

$$\text{Percentage of Defective Products} = \frac{\text{defect}}{\text{production amount}} \times 100\% \ldots\ldots\ldots (1)$$

note :
defect = number of defective products
production amount = number of products produced

3. Identify the types of defects according to their priority level using the Pareto diagram

b. Measure

Calculating DPU, DPO, DPMO, and sigma levels to measure the extent of the company's effectiveness in reducing defective products.

$$\text{DPU} = \frac{\text{defect}}{\text{production amount}} \ldots\ldots\ldots (2)$$

$$\text{DPO} = \frac{\text{defect}}{\text{production amount x CTQ}} \ldots\ldots (3)$$

$$\text{DPMO} = \text{DPO} \times 1.000.000 \ldots\ldots (4)$$

$$\text{level sigma} = \text{normsinv}\left(\frac{100000 - \text{DPMO}}{1000000}\right) + 1{,}5 \ldots\ldots (5)$$

note :

DPU = defects per unit
DPO = defect per opportunity
DPMO = defect per million opportunity
Defect = number of defective products
Production quantity = number of products produced
Normsinv = functions in Excel return numeric values

c. Analyze

A logical outline of conditions and results or a fishbone diagram is very important for the seven instruments used to assess the basic causes of problems that occur (Permono et al., 2022).

d. Improve

Each deformity has its fundamental drivers, including human, machine, material, strategic, and natural factors, this is a reason to think critically. The maintenance cycle is carried out in stages for one type of defect and within a certain period, this is because the maintenance process is centered on the main approach to overcome that type of defect (Radianza & Mashabai, 2020).

e. Control

This damage to goods must be prevented through quality control to distinguish the causes of goods damage reduce goods defects (Arifin et al., 2019), and further increase process capacity towards Six Sigma targets.

2.4 Research Flow Chart

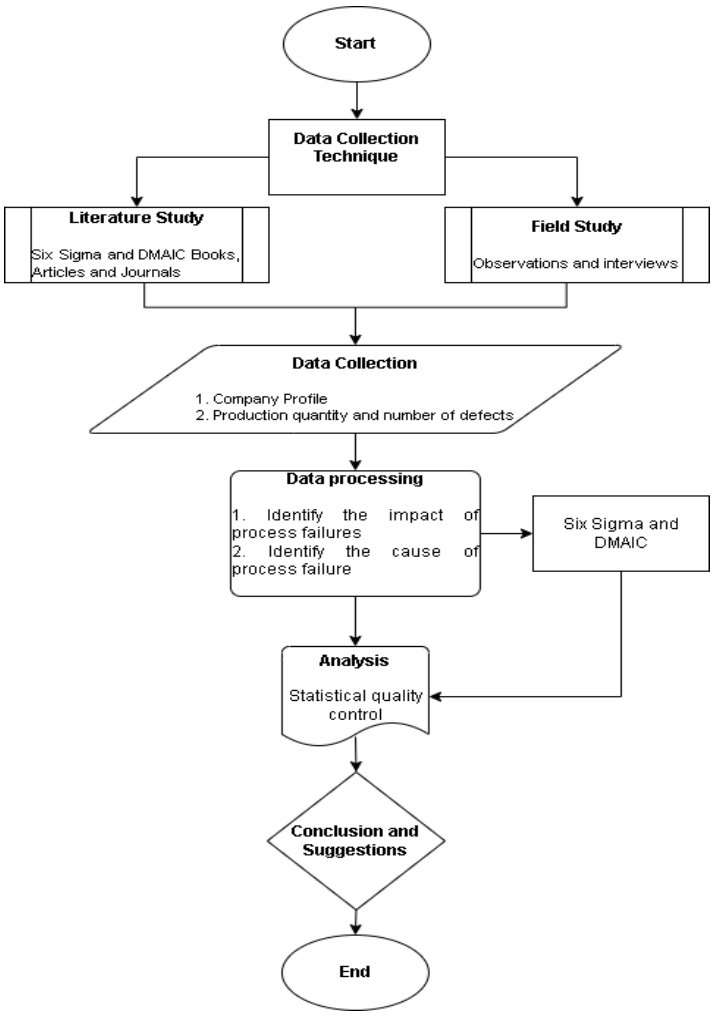

Fig. 1. Research flow chart.

3. RESULT AND DISCUSSION

The following is an illustration of quality control using the Six Sigma DMAIC method on test liner paper.

3.1 Define stages

This stage determines the type of defect and determines the largest number of defects in the product so that action can be taken to reduce defects.

Table 1. Types of defects in test liner products

Types of Defects	Specification
Broken edge	The condition of the paper is torn/broken at the edges
Under GSM	The paper is below company standards of 125-200 gsm
Stick	Separate the worst or the least size and weight.
Bad cross-section	The cuts are angled and thin, so there is no visible paper progress or cut edges going in and out.
Connect 3 times	Paper connection more than 3 times

Table 2. Number of defects in test liner products

Types of Defects	Number of defects (kg)	Percentage (%)	Cumulative Frequency (kg)	Cumulative Percentage (%)
Broken edge	18.400	52	18.400	52
Bad cross-section	12.406	35	30.806	88
Under GSM	2.128	6	32.934	94
Connect 3 times	1.100	3	34.034	97
Stick	1.050	3	35.084	100

Based on Table 2, the most common type of deformity is edge fracture, while the least common type of imperfection is sticking. Determination of the dominant type of deformity is carried out using the Pareto diagram.

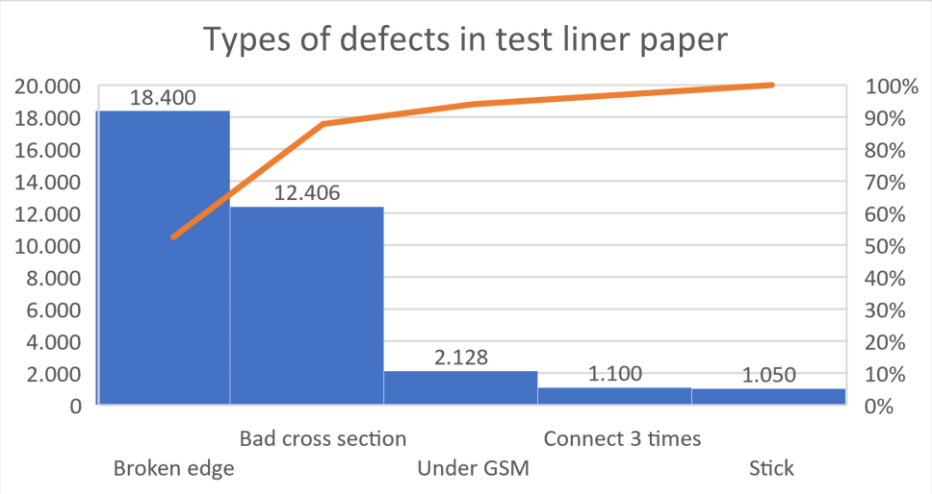

Fig. 2. Pareto Diagram Types of Product Defects .

Based on the Pareto outline above, the most common types of deformities that occur in Test Liner paper products are broken edges and poor cross-sections.

3.2 Measurement stages

At this stage, the company measures the Sigma value using the Defect Per Million Opportunities (DPMO) measure.

Table 3. Daily production data

Day and date	Production quantity (kg)	Number of defects (kg)	CTQ
Thursday (24-8-23)	183.000	4.500	5
Friday (25-8-23)	166.000	5.500	5
Sunday (27-8-23)	214.050	6.956	5
Monday (28-8-23)	180.785	18.128	5
Total	953.625	35.084	20

Calculating DPU value:

$$\text{DPU} = \frac{4.500}{183.000} = 0{,}024590164 \quad (2)$$

$$\text{DPO} = \frac{4500}{183.000 \times 5} = 0{,}004918033 \quad (3)$$

$$\text{DPMO} = 0{,}004918033 \times 1.000.000 = 4918{,}032787 \quad (4)$$

$$\text{level sigma} = \text{normsinv}\left(\frac{100000 - 4918{,}032787}{1000000}\right) + 1{,}5 = 4{,}08 \quad (5)$$

Table 4. Result of sigma value calculation

Day and date	Production quantity (kg)	Number of defects (kg)	CTQ	DPU	DPO	DPMO	Sigma level
Thursday (24-8-23)	183.000	4.500	5	0,024590164	0,004918033	4918,032787	4,08
Friday (25-8-23)	166.000	5.500	5	0,03313253	0,006626506	6626,506024	3,97
Sunday (27-8-23)	214.050	6.956	5	0,03249708	0,006499416	6499,416024	3,98
Monday (28-8-23)	180.785	18.128	5	0,100273806	0,020054761	20054,76118	3,55
Total	953.625	35.084	20	0,19049358	0,038098716	38098,71602	

Based on table 4, it shows that the lowest Six Sigma level results were 3.55 on the fourth day and the highest on the first day was 4.08.

3.3 Analysis stages

The investigation stage means finding the main drivers of quality problems that occur. The tool used for examination is a fishbone diagram.

a. Broken edge

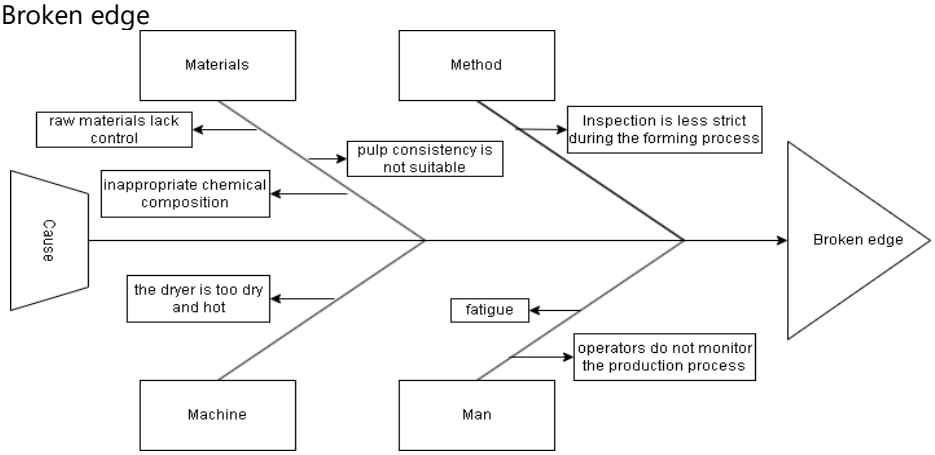

Fig. 3. Fishbone diagram for broken edges.

b. Bad cross section

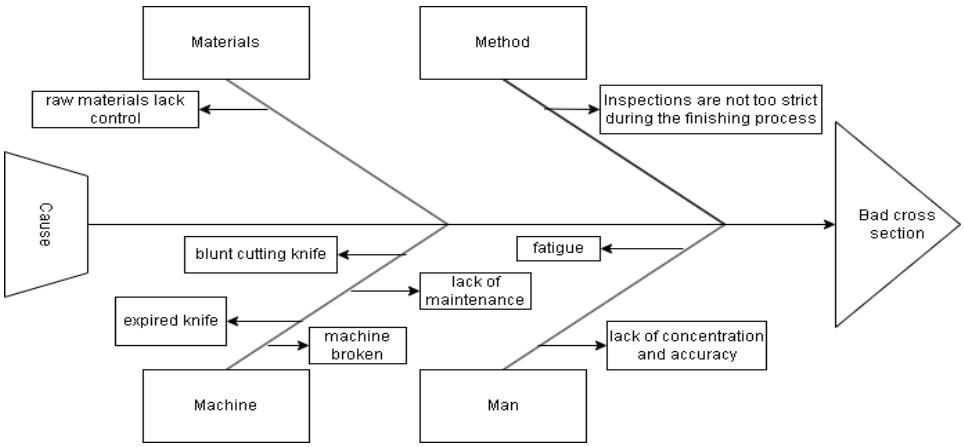

Fig. 4. Fishbone diagram for the bad cross-section.

The fishbone diagram is a tool to explain the relationship between problems, the sources of their causes, and the factors that influence them (Ahmad et al., 2024). The image above shows four indicators starting from people, raw materials, methods, and machines used to identify the causes of product defects.

3.4 Improvement stages

At this stage, recommendations for improvement are given to the main problems that cause broken edge defects and poor cross-sections on the test line paper.

Table 5. Improve activation of defective products

No	Production factors	Define	Analyze	Improve
1	Materials	Broken edge	Raw material lacks control, pulp consistency is not suitable, inappropriate chemical composition	The sorting of raw materials is tightened, and the operator controls the addition of water in the hydro pulper
		Bad cross-section	Raw material lacks control	The sorting of raw materials is tightened
2	Man	Broken edge	Fatigue, operators do not monitor the production process	Improving worker facilities and infrastructure, the production head carries out intensive inspections of operator work
		Bad cross-section	Fatigue, lack of concentration and accuracy	Improving worker facilities and infrastructure
3	Methods	Broken edge	Inspection is less strict during the finishing process	Tighten inspection
		Bad cross-section	Inspections are not too strict during the finishing process	Tighten inspection
4	Machine	Broken edge	The dryer is too dry and hot	Carry out regular machine maintenance
		Bad cross-section	Blunt cutting knife, lack of maintenance, expired knife, machine broken	Carrying out regular machine checks, replacing spare parts, making machine maintenance schedules

3.5 Control stage

After the testing and repair phase is complete, control is then carried out on each part so that the efforts made can be carried out continuously without repeating similar mistakes. Reducing product defects, and more effective utilization of raw materials, machines, and employees will all have a direct impact. In this regard, several control efforts are required as follows:

a. Materials

Reorganizing standards for the use of raw materials and supervision of managers who combine ingredients.

b. Man

Make this framework a representative activity or step in developing further implementation which is then used as a task to create standards for employees so they can work according to the standards created.

c. Method
Monitor and refine SOPs as a reference for operators.

d. Machine
Reset the engine check frequency.

4. CONCLUSION

Data collection was carried out over four days with total production of 953,625 kg with a total defects of 35,084 kg. From the results of research and data processing using the Six Sigma DMAIC method, it can be concluded that the biggest defect in test liner paper products at PT. Lohdjinawi Widjaya total broken edge defects 18,400 kg or 52%, damaged cross-section 12,406 kg or 35%. Four factors influence product quality including materials, people, methods, and machines. There are several efforts to minimize production failures according to the causal factors, including; sorting of raw materials is tightened, the operator controlling the addition of water in the hydro pulper, improving worker facilities and infrastructure, tightening inspection, and carrying out regular machine maintenance.

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