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Analysis of Carton Packaging Quality Control Using Statistical Quality Control Methods at PT XYZ

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Abstract:-This research focuses on analyzing the quality control of cardboard box packaging at PT XYZ using the Seven Tools method. The main problem faced by the company is the high level of defects in the cardboard box products produced, which has a negative impact on production efficiency and customer satisfaction. The aim of this research is to analyze the main causes of defects in cardboard box products and provide suggestions for improvements that can be implemented by companies. The method used in this research is Statistical Quality Control (SQC) which involves the use of Seven Tools, namely check sheets, Pareto charts, fishbone diagrams and control charts. Using these tools, data regarding defects is collected, analyzed, and interpreted to identify the main causal factors of quality problems. The analysis results show that certain factors, such as the quality of raw materials, production processes, and operator skills, have a significant contribution to the occurrence of defects. Based on these findings, this research proposes several improvements that can be implemented by PT XYZ to improve the quality of their cardboard box products. Proposed improvements include increasing control over the quality of raw materials, skills training for operators, and implementing stricter standard operational procedures in the production process. By implementing this proposed improvement, it is hoped that PT XYZ can reduce the level of defects in their products, increase production efficiency, and increase customer satisfaction.

Keywords:- *Quality Control, Defect, Seven Tools, Statistical Quality Control, Why Why Analysis, Improvement Proposals.*

I. INTRODUCTION

Quality control must be able to direct several goals in an integrated manner, so that consumers can be satisfied using the company's products or services. Quality control is an activity that is often carried out by every company. If quality control is carried out well, the company will incur additional costs, namely quality control costs, and the level of product damage produced is very low or only a few damaged products occur. Quality is one of the important dimensions in products and processes, this will show the competitive advantage of a company versus other companies (Zonnenshain & Kennet, 2020)[1]

The business world is becoming more competitive in the modern era. Competition is not limited to the domestic market; it is now on the global stage. Any company operating in a highly competitive market must constantly compete with other businesses operating in the same sector. All company tactics and strategies to maintain competitiveness and survive in worldwide competition with other companies' products have been influenced by quality difficulties (La Hatani, 2007) [2], good quality results from good processes and meets standards that have been determined based on market needs. A company located in Cikarang, West Java. This company operates in the logistics, export and import business sectors. Company XYZ involves strategic aspects other than standard logistics which include transportation, warehousing, packaging and distribution processes and logistics information. One of the advantages of the product is the packaging, the appearance of the packaging meets shipping standards for export. However, the packaging process cannot be separated from problems or NG (Not Good) products, including dirty, torn and dented products. To analyze the factors causing the existence of these NG products, quality control is needed. The strategy that can be used to control product quality in each preparation is a factual control strategy or what is usually called Statistical Quality Control (SQC), which is a framework created to maintain production quality measures, at least at a level that uses measurable strategies to analyze information.

From packaging data for the last 3 months, Deefct that has been produced on the packaging line from total production is 3125 pcs with a gross defect presentation of 6.08%, dents of 4.38% and tears of 9.89%.

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Table 1 Defect Percentage

No	Month	Production Amount	Dirty	Dent	Ripped
1	April	1225	58	40	93
2	May	1000	44	34	78
3	June	900	88	63	138
Total		**3125**	**190**	**137**	**309**
Percentage		**100.00%**	**6.08%**	**4.38%**	**9.89%**

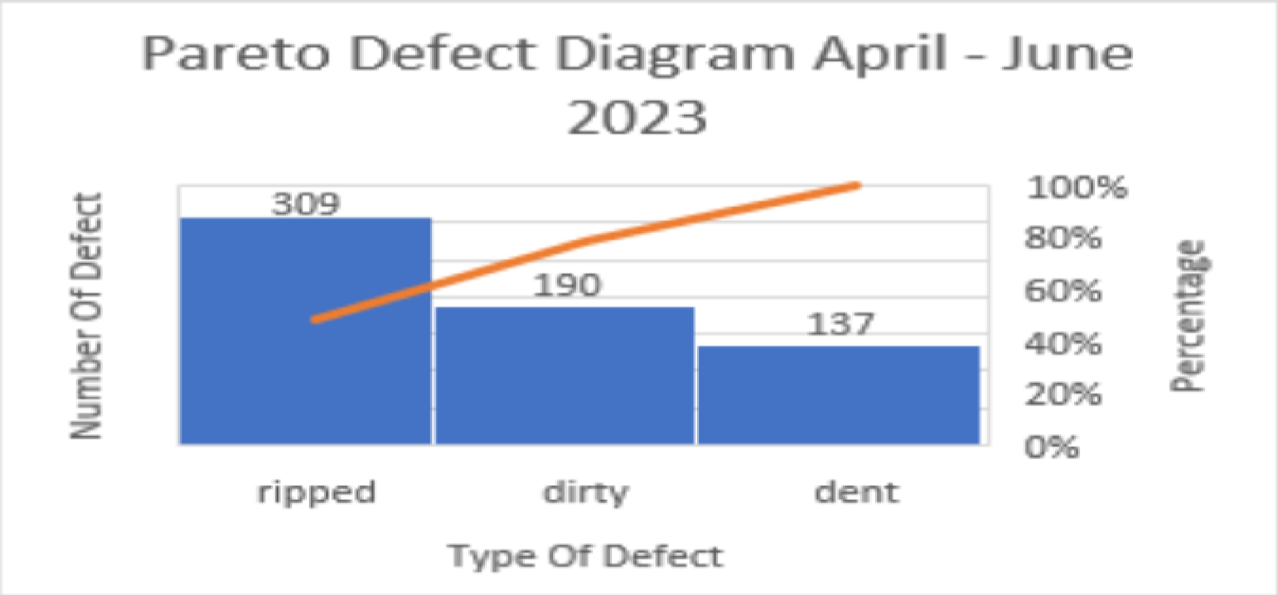

Fig 1 Pareto Diagram

The results of Figure 1 show the number of defects for the period April - June 2023, as well as the types of defects that occur in Figure 1. The most common defects shown in the Pareto diagram are tear defects. From the overall production results, this is not a small number, therefore there must be improvements and quality control to reduce the presentation of defects.

II. LITERATURE REVIEW

➢ *Quality*

Quality is the main factor in determining whether consumers subscribe to the product. Customers will feel satisfied if the product provided is of high quality and meets their needs. According to (Assauri 2016:317) [3], When qualities are prioritized to meet the wants and desires of customers, the emphasis is on those attributes. explains that quality is a dynamic state that affects environments, people, processes, goods, and services that meet or exceed expectations. The American Society for Quality defines it as the general qualities and attributes of a good or service that can meet specific or general demands. Thus, the business makes a constant effort to uphold the caliber of its output in order to consistently provide high-quality goods and sustain customer happiness. (2011) Heizer and Render[4]

➢ *Quality Control Objectives*

The primary objective of quality control is to ensure that the quality of the goods and services that are manufactured does not fall short of the quality standards that have been established at a cost that has also been established. The process of controlling production in terms of both quality and quantity is an extremely significant activity in a company. This activity should be as economical or as low as feasible. As stated in the article (Assauri, 2008:299) [5], the objectives of quality control are:

- Production goods are able to meet the specified quality requirements.
- Try to minimize inspection costs.
- Make efforts to minimize the design costs of goods and procedures that use certain manufacturing attributes.
- Strive to keep production costs as low as possible. Determining the extent to which the process and output of a good or service complies with the standards set by the company is the main objective of quality control. The following are general quality control objectives as stated by (Heizer & Render, 2013) [6]are as follows:

✓ To ensure that the finished product meets the quality standards that have been set.
✓ To allow for efficient expenses associated with product design, inspection, and production.
✓ The fundamental tenet of quality control is that processes must be continuously achieved and improved in order to generate data that can be utilized for process control and improvement, enabling the process to meet customer-desired product specifications. Therefore, the primary goal of quality control is to ensure that the produced good or service satisfies the established requirements for quality while incurring the fewest feasible expenses..

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➢ *Factors that Influence Product Quality*

According to (Assauri, 2015:362) [7]there are 9 general factors that influence quality which are commonly known as 9M, namely:

- Market (Market)
- Money (Money)
- Management (Management)
- Men (Human)
- Motivation (Motivation)
- Material, Machine and Mechanization (Materials, Machines and Mechanization)
- Modern information method (Information methods and mechanisms)
- Mounting product requirements (production process requirements)

➢ *Dimensions of quality*

According to (David Garvin 1987) [8], determining the dimensions of product quality can be done through eight dimensions, namely performance, features, reliability, suitability, durability, service ability, aesthetics, image or reputation.

- Performance (Performance), the extent to which a product or service fulfills its function as expected.
- Features, additional characteristics that complement the basic function of a product or service.
- Reliability, the ability of a product or service to function properly during a certain period.
- Conformance (suitability), the extent to which a product or service meets certain specifications or standards.
- Durability, the product's lifespan or the ability of the product to continue to be used before it needs to be replaced.
- Serviceability (Ease of Repair), ease and speed in repairing products or services.
- Aesthetics, the look, feel, sound, smell, or other sensory impression of a product or service.
- Perceived Quality, the general impression that consumers have about product quality

➢ *Understanding Statistical Quality Control*

Statistics is a decision making tool that involves the process or analysis of information contained in a sample. In quality assurance, statistical methods play an important role . This is a system developed to maintain production quality standards at minimum costs, using statistical methods to collect and analyze data. Statistical Quality Control (SQC), in which the quality of the production process is managed beginning with the beginning of production, continuing through the manufacturing process, and ending with the final product, is a method that is utilized for the purpose of controlling and managing the items that are created. Before the product is released to the market, it is first subjected to an inspection, during which the items that have been manufactured are split into two categories: those that are of high quality and those that are not.

According to (Nasution 2017:39) [9], The statistical approach known as statistical quality control (SQC) is a technique that applies probability theory to the process of testing or analyzing samples. Quality assurance and control procedures for the product. In acquainted with (Sumayang 2007:272) [10] Quality control known as Statistical Quality Control (SQC) makes use of basic statistics to find and remove variations that are not random or that arise just once throughout the manufacturing process. With the tools included in SQC, quality control may be performed statistically. According to Heizer and Render (2006), statistical quality control is a procedure used to uphold standards, measure, and address issues with manufactured goods or services. [11]In addition to monitoring the process and quality of the products being worked on, statistical quality recognition can be used to approve or reject goods that have been made.

The theoretical framework used in this research shows how statistical quality control can help in assessing the level of damage to cardboard packaging, determining the reasons behind it, and then investigating potential improvements to the problem to produce suggestions or recommendations for improving production. quality going forward.

III. RESEARCH METHODS

➢ *Research Design*

In particular, systematic scientific research on components and phenomena as well as the cause and effect correlations of these interactions is used in this study as a form of quantitative research. The methodical study of phenomena through the collection of quantifiable data by statistical, mathematical, or computer methods is known as quantitative research. The quantitative research techniques put forward by (Sugiyono 2009: 14) [12] may be seen as a research method that is founded on the philosophy of positivism and is utilized for the purpose of conducting research on specific populations or samples. The various sampling approaches are typically carried out in a random fashion, research tools are utilized for data collecting, and quantitative and statistical analysis is performed with the intention of testing hypotheses.

➢ *Data Collection Methods*

In research, data collection techniques are an important factor for the success of the research. This relates to how to collect data, who the source is, and the method used. The type of data used in this research is divided into two, namely:

- Primary data is data obtained from direct observations in the field. The primary data required for the investigation of XYZ company is as follows:

✓ The method of documenting organized patterns in the actions of subjects (individuals), things, or occasions without speaking to or interrogating the subject. Pay close attention to the procedure of packing the product.
✓ Interview. The data collection technique in the research method uses verbal questions to investigate a topic. Interviews can be done directly via telephone.

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- Secondary data generally takes the form of historical evidence, notes or reports (document data) compiled in published and unpublished archives. This data was obtained through a direct data request from the Company. The secondary data needed to investigate company XYZ is as follows.

- ✓ A Data on the number of defective products per day.
- ✓ production volume data.

➢ *Analysis Method*

The collected data and information are processed and analyzed further by:

- Descriptive analysis which aims to obtain an in-depth picture of the quality control of cardboard box packaging carried out at PT. XYZ.
- The quality control method that the author uses is Statistical Quality Control (SQC), as for the steps in using the statistical quality control method.

➢ *Statistical Quality Control Tools*

(Heizer and Render, 2015) [13]the stages of Statistical Quality Control (SQC) are as follows.

- *Check Sheet*

To capture data, a formula known as a “cheek sheet” is used. In many cases, recording is done to make it easier to identify patterns when data is collected. Through the use of check sheets, analysts can identify facts or trends that may be beneficial to their research.

Table 2 Cheek Sheet

Type of Defect	Count	Score
Dirty	卌 卌 ||	12
Broken stitching	卌 卌 卌 卌 卌 卌 卌 卌 ||	42
Inconsistent margin	卌 卌 卌	15
Wrinkle	卌 卌 卌 卌 卌 卌	30
Long thread	卌 卌	10
Padding shape	卌 |||	8
Off center	卌 卌 卌 |||	18
Stitch per inch	卌 卌 卌 卌 ||||	24
Others	卌 卌 卌 卌 ||	22
	Total Defects:	**181**

- *Pareto Chart*

In order to make it easy to read or explain data quickly, the data needs to be presented in the form of a Parerto diagram which is a visual data presentation tool in the form of block graphics that pays attention to the distribution of the values obtained in the form of numbers.[14]

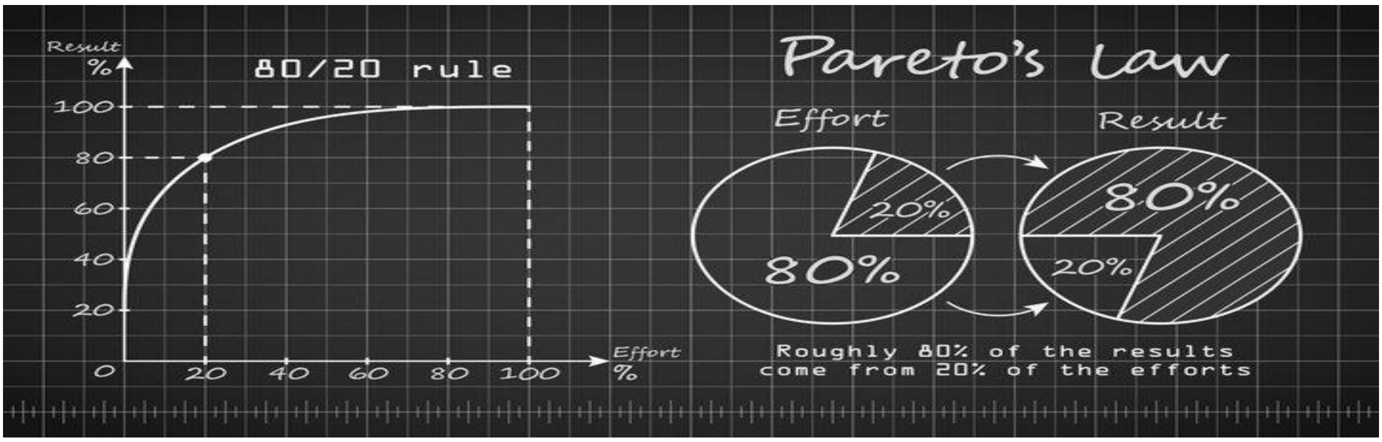

Fig 3 Pareto Diagram

- *Control Map (P – Chart)*

Attribute control charts (Proportion Control Maps) in analyzing data, P control charts (Proportion Control Maps) are used as a tool for statistical process control. The use of the P control chart is because the product is damaged and cannot be repaired so it must be rejected.

✓ *Calculate the percentage of damage*

$$P = \frac{np}{n}$$ Information:

np : Number of failures

n : Number checked

✓ *Calculating the center line (CL)*

$$\frac{\sum n_P}{\sum n}$$

- *Information :*

$\sum n_P$: Total number of damaged cardboard boxes

$\sum n$: Total number of cardboard boxes inspected

✓ *Calculating the Upper Control Limit, to calculate the upper control limit or UCL using the formula:*

$$UCL = P + 3 \frac{P(1-P)}{ni}$$

- *Information :*

$\bar{p}$: Average damage to cardboard boxes

n : Number of months examined

✓ *Calculating the lower control limit or Lower Control Limit (LCL) to calculate the lower control limit or LCL is done using the formula:*

$$LCL + P - 3\frac{P(1-P)}{ni}$$

- *Information:*

$\bar{p}$: Average damage to cardboard boxes

n: Number of months checked (note: If LCL <0 then LCL is considered = 0)

- *Fishbone Diagram*

Another tool for identifying quality problems and inspection points is a cause-and-effect diagram, which is also known as an Ishikawa Diagram or Fishbone Chart. This diagram is shaped like a fishbone to illustrate a quality control problem, where each bone represents a possible source of error.

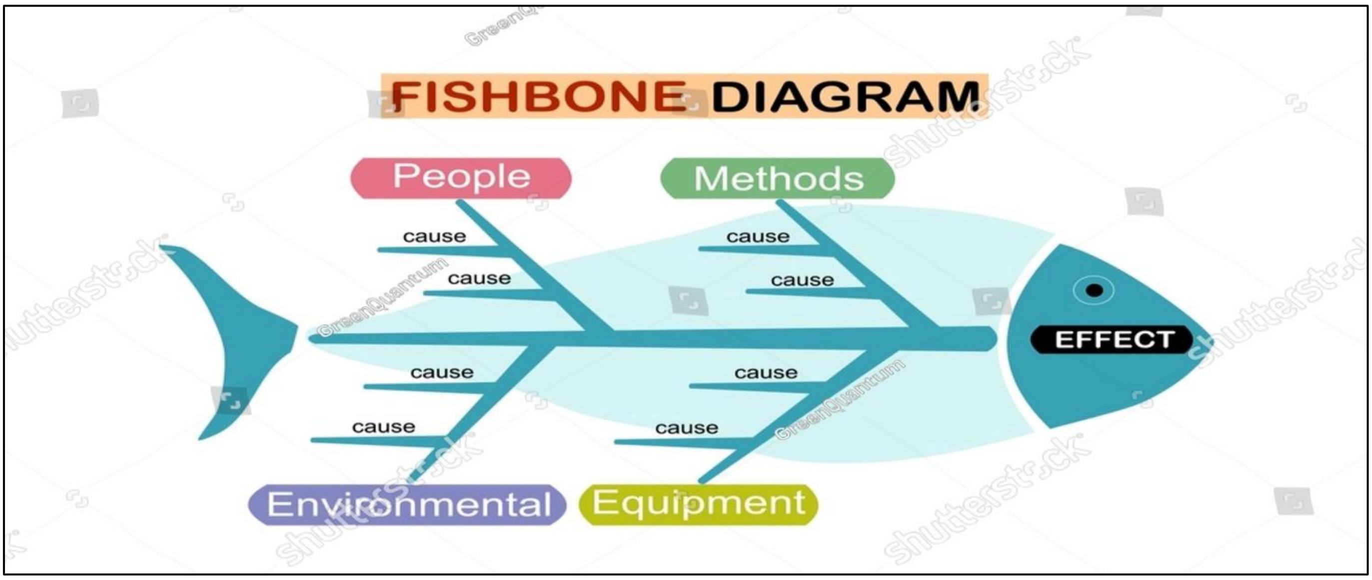

Fig 4 Fishbone Diagram

IV. RESULTS AND DISCUSSION

In this section, data analysis is carried out to identify problems and to find out the root cause of the problem so that improvement proposals can be obtained to minimize defects in cardboard packaging production.

➢ *Data collection*

This research was conducted in the period April – June 2023 at PT. XYZ is located in the MM2001 industrial area, Bekasi Regency. The data collection carried out was secondary data collection in the form of cardboard box packaging production data and the number of defects for 3 months. Data on cardboard box defects can be seen in **Table 1** below.

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Table 3 Production Amount

No	Month	Production Amount	Dirty	Dent	Ripped
1	April	1225	58	40	93
2	May	1000	44	34	78
3	June	900	88	63	138
Total		3125	190	137	309

Based on **Table 3** , it is known that during observations from April to June the production amount was 3125 pcs with a total of 636 defective pcs.

➢ *Statistical Quality Control Method*

In research using Statistical Quality Control, statistical analysis tools will be used, namely check sheets, Pareto diagrams, control charts and fishbone diagrams. The use of these four tools is considered to have met the research objectives, namely to determine the factors that cause product defects in the cardboard box packaging process. The four statistical analysis tools are as follows:

- *Cheek Sheet*

The first stage in quality control analysis to create a cheek sheet or inspection sheet is to compile a table containing columns for date, production quantity, type of damage and number of defects. The results of data collection via cheek sheets which were carried out over the 3 month period April – June 2023 can be seen in Table **2** below.

Table 4 Cheek Sheet Number of Production and Defects

No	Month	Production Amount	Dirty	Dent	Ripped
1	April	1225	58	40	93
2	May	1000	44	34	78
3	June	900	88	63	138
Total		3125	190	137	309
Percentage		100.00%	6.08%	4.38%	9.89%

Based on **Table 2** of the cheek sheet above, it can be seen that the number of cardboard box packaging production in April 2023 is 1,125 pcs with gross defects of 58 pcs, 40 pcs of dents and 93 pcs of tears. In May PT. XYZ produces cardboard box packaging with a total production of 1000 pcs with details of gross product defects of 44 pcs, 34 pcs of dents and 93 pcs of tears. In June PT. XYZ produces 900 pcs of cardboard box packaging with details of gross product defects of 88 pcs, 63 pcs of dents and 138 pcs of tears. Based on the cheek sheet, it was found that the total packaging for the period April – June 2023 was 3,125 pcs with a total of 190 gross defects, 137 pcs dented and 309 pcs torn.

- *Pareto Chart*

After the cheek sheet, the next step is to create a Pareto diagram. This Pareto diagram is useful for seeing the types of damage that occur most frequently.

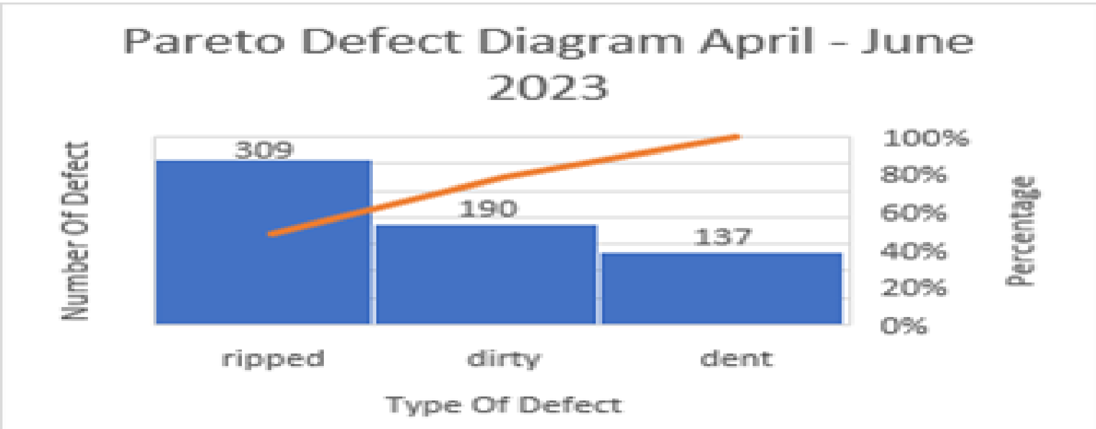

Fig 5 Product Defect Pareto Diagram in April – June 2023

Based on the Pareto diagram above, we can see that the type of damage that occurs most frequently is tearing, with a total of 309 damages.

- *Control Chart*

After making a check sheet and Pareto diagram, the next step is to make a control chart which functions to see whether quality control in this company is under control or not. As previously discussed, the initial steps in creating a control chart are as follows:

- Calculate the damage percentage.
- Calculating the central line (CL).
- Calculating the Upper Control Limit (UCL).
- Calculating the Lower Control Limit (LCL).

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- *Calculating the Central Line (CL)*

It is the line that is in the middle of the control limit (UCL) and the lower control limit (LCL) that is referred to as the central line. It is a line that indicates the typical amount of damage that occurs throughout the production process. This line is the center line. Make use of the formula in order to determine the center line:

$$CL = p = \frac{\sum n_P}{\sum n}$$

- *Information :*

$\sum n_P$: Total number of damaged cardboard boxes.

$\sum n$: Total number of cartons checked.

Based on the formula above, the Central Line is obtained as follows:

$\sum n_P$: 309 pcs

$\sum n$: 3125

$$CL = p = \frac{309}{3125} = 0.0989$$

- *Calculating the Upper Control Limit (UCL) and Lower Control Limit (LCL)*

The upper control limit and lower control limit are statistical indicators of whether a process can be said to be deviant or not. The upper control limit (UCL) can be calculated by the formula:

$$UCL = P + 3(\sqrt{\frac{\bar{p}(1-\bar{p})}{n}})$$

- *Information :*

p : Average product damage

n : Total month checked

Based on the formula above, the upper control limit can be obtained as large.

p : 0.0989

n :3

$$UCl = p + 3(\sqrt{\frac{p(1-p)}{n}}) = UCL = 0{,}0989 + 3(\sqrt{\frac{0{,}0989(1-0{,}0989)}{3}}$$

$= 0{,}2255$

Meanwhile, to calculate the Lower Control Limit (LCL) use the formula:

$$LCL = \bar{p} - 3(\sqrt{\frac{\bar{p}(1-\bar{p})}{n}})$$

- *Information :*

$\bar{p}$: Average product damage.

n : Total month checked.

Note: If LCL < 0 then LCL is considered = 0

$\bar{p}$: 0.0989

n :3

$$LCL = p + 3\left(\sqrt{\frac{p(1-p)}{n}}\right) = UCL = 0{,}0989 - 3(\sqrt{\frac{0{,}0989(1-0{,}0989)}{3}}$$

$= -0{,}0278$

After the values for the percentage of damage for each group, the CL value, the UCL value, and the LCL value are obtained, the next step is to create a control chart (Control – Chart). The p control chart was created using the Microsoft Excel 2016 program.

This is a measurement sheet that was created by obtaining samples from April through June in order to ascertain the values of the Central Line (CL), Upper Control Limit (UCL), and Lower Control Limit (LCL) (Lower Control Limit).

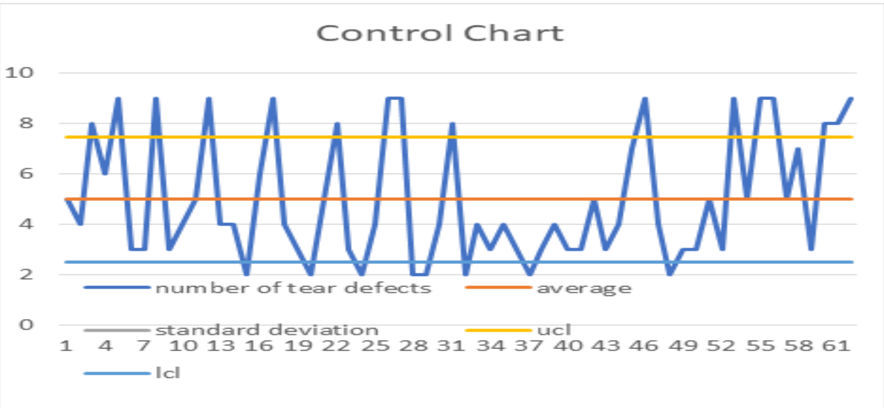

Fig 6 Control Chart

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As a rule of thumb (Prawirosentono, 2002) [15], the following criteria are used:

- ✓ Determine the reason if P < LCL, which indicates that all samples are in the receiving region (LCL).
- ✓ Samples are considered to act normally or have adequate processing capability if LCL <P> UCL, which indicates that all samples are in the receiving region.
- ✓ If P > UCL, it indicates that the sample has jumped outside of the reception area (UCL) or that the process capability is inadequate. Investigate the reasons and improve performance in the production process activities to address the issue.
- ✓ Because P is above the UCL limit, the process capability is not running well, so the cause must be checked and corrective action taken by increasing performance in production process activities.

- *Fishbone Diagram*

A cause – effect diagram also known as an Ishikawa or "fishbone" diagram is a graphical tool used to explore and display the possible causes of a particular effect. Fishbone diagrams are used when causes are grouped naturally based on the categories of materials, methods, equipment, environment and people.

- ✓ The first and most important are workers, namely workers who are actively involved in industrial processes.
- ✓ The components used in the process of making a product into finished goods, are also called raw materials.
- ✓ Equipment, also called tools, consists of various tools used during the production process.
- ✓ Method, namely instructions for the manufacturing process or work orders that must be obeyed
- ✓ Environment, namely the conditions around the production site, which have an impact on the production process, both directly and indirectly.

We can see in **Figure 5,** namely the Pareto product diagram where there are three types of defects that arise in the production process, namely dirty, dented and torn. As a tool to find the cause of the damage, a fishbone diagram is used to determine the type of damage.

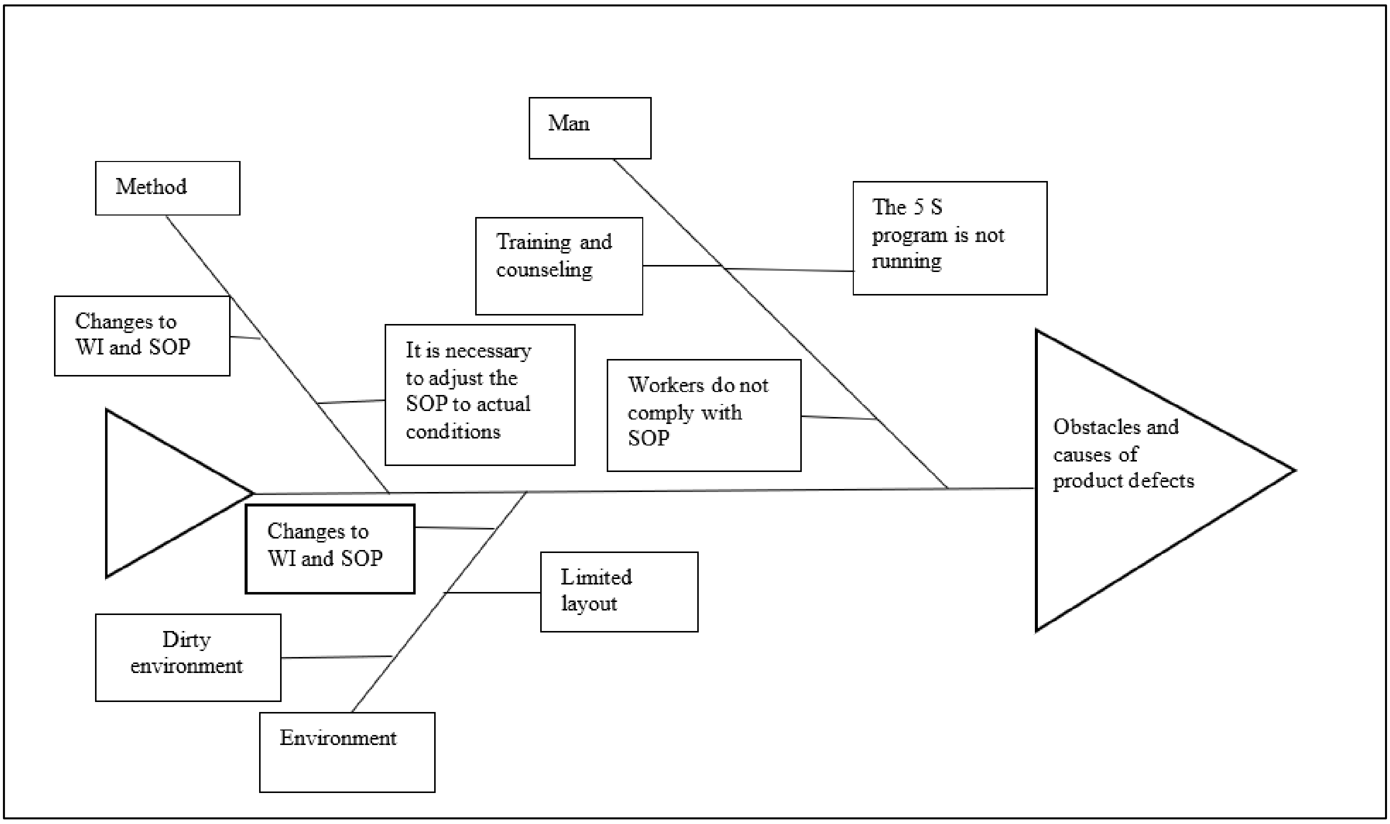

Fig 7 Fishbone Diagram

- *Factors that Become Obstacles and Causes of Product Defects*

- Why-Why Analysis is a systematic approach to identifying the root cause of a problem by asking successive "why" questions until reaching the underlying root. Previously, the use of tools such as check sheets for data collection, Pareto diagrams to highlight the main causes based on the 80/20 principle, and control charts to control processes statistically, could provide important initial insights. Why-Why Analysis deepens understanding of the cause-and-effect sequence involved in problems, enabling the implementation of more targeted and effective corrective actions in an effort to improve process quality and efficiency.

Table 3 Why – Why Analysis

Problem	Why 1	Why 2	Why 3	Why 4	Why 5
The cardboard box experienced a defect in the form of a tear during the packaging process.	Cardboard boxes are not able to withstand the pressure or load received.	Packaging operators are poorly trained or do not follow standard operating procedures (SOP).	Packaging operators are poorly trained or do not follow standard operating procedures (SOP).	Management does not give priority to employee training and development.	Operational standards are not updated..

- *Fishbone Diagrams*

After explaining the importance of Why-Why Analysis as a tool for systematically identifying the root causes of problems, the next step in exploring the causes of complexity is to use the Fishbone Diagram, also known as the Ishikawa Diagram. Why-Why Analysis helps ask "why" questions sequentially to explore the main factors influencing a problem, while Fishbone Diagram visualizes these causes in broader categories such as man, machine, method, material, environment, and measurements. After doing a Why-Why Analysis, we may more clearly understand the link between complicated causal elements and create a more targeted and comprehensive improvement approach by using the Fishbone Diagram.

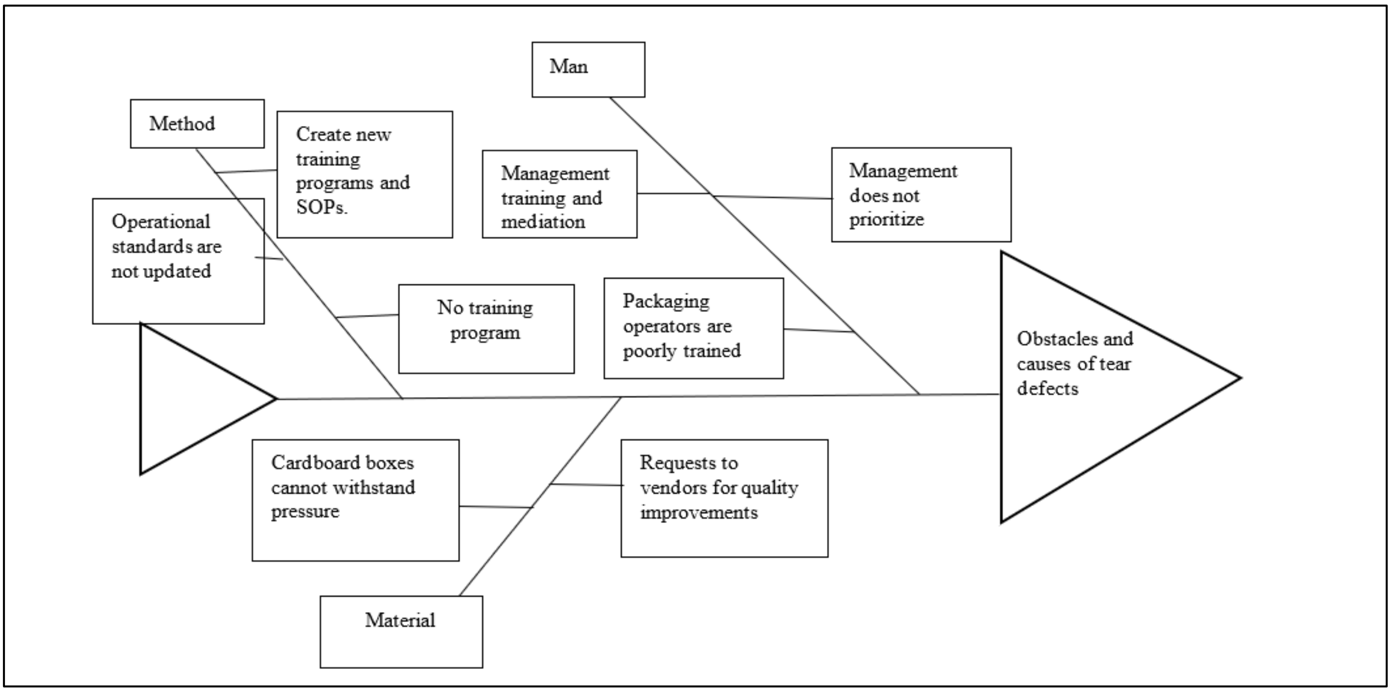

Fig 8 Fishbone Diagram Torn Defect

- *Improvements*

After knowing the causes of deviations that result in defects in cardboard box products, a proposal for general corrective action is prepared in an effort to reduce the level of product defects.

Table 4 Improvements

No	Sumber Penyebab	Faktor Penyebab	Improvement
1	Man	1. Workers do not comply with the SOP.	1.Training and counseling.
2	Method	1. It is necessary to adjust the SOP to actual conditions.	1. Changes to WI and SOP.
3	Environment	1.Limited packaging operator layout.	1.Layout settings.

- *Discussion*

This research aims to analyze the quality control of cardboard box packaging at PT. XYZ. This analysis was carried out using product defect data for the period April to June 2023. In an effort to implement quality control to reduce the level of damage to PT. XYZ sets production quality standards for defective product targets set at 5% of the total production amount. From observations and data collection carried out over three months, it can be seen that the product defects that occur are quite high, there are three types of product defects, including dirty (6.08%), dented (4.38%) and torn (9.89%) on From this data, it is known that there are two types of defects that exceed the production quality standard tolerance limits, namely, dirty (6.08%) and torn (9.89%). Companies need action that can overcome these problems, Statistical Quality Control is a statistical tool that can be used to carry out quality control as well as determine the priority of the greatest damage, find the cause of damage and determine control limits "Titop Dwiwarno, 2009"

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Based on the results of analysis through control charts, it can be concluded that the cardboard box packaging production process at PT. XYZ is not good, so the process capability is not running well, so the cause must be checked and corrective action taken by increasing performance in production process activities. Furthermore, it can be seen in the fishbone diagram and Why Why Analysis, the main cause of product defects is the human factor where humans/workers do not carry out the SOP that has been created, the method requires adapting the SOP to actual conditions and an unclean work environment and layout. limited.

V. CONCLUSION

- Based on the Pareto diagram created, it can be seen that the highest *defect level is torn defects* with a total of 309 pcs with a percentage of (9.89%). The second highest *defect* rate was gross with a total of 190 pcs with a percentage of (6.08%). And the lowest *defect level* below the standard set by the company at 5% is dent *defects* with a total of 137 pcs with a percentage of (4.38%). Meanwhile, the total *defects* during the three month period from April to June were 636 pcs out of a total production of 3125 pcs.
- From the results of the control chart , the process capability is not running well, so the cause must be checked and corrective action taken by increasing performance in production process activities. there is a need for quality control. This is an indication that the process is not running well.
- Based on the results of *the fishbone* diagram analysis and *Why* **-** *Why Analysis*, it can be seen that the factor that causes the most damage or *defects* is tearing products in the *packaging process*, which comes from human factors (workers), work methods, and materials

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