Statistical Quality Control Analysis of Bottled Water Products

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Abstract

Every manufacturing and service business actor needs to carry out quality control in order to maintain the quality of the products produced. One of the companies engaged in manufacturing and producing bottled water is PT. Oasis Waters International. This research aims to control defects in 240-ml cup bottled water products using the Statistical Quality Control (SQC) methods. The data collection method used is observation and interviews, followed by processing the data using the SQC method, the stages include filling out a check sheet, making a histogram, making a pareto diagram, and making a cause-and-effect diagram. It was found that there were five defects that occurred during the production of 240 ml of bottled water, such as unknown objects, insufficient water volume, an outer cup reject, an inner cup reject, and a broken cup. In data processing using the Statistical Quality Control (SQC) method, the largest percentage of defects was found, namely outer cup reject defects at 53.18%. Actions taken to reduce damage to the outer reject cup with the proposed placement of visual controls that are advanced near the conveyor where accumulation occurs.

Keywords: *Quality, Statistic Quality Control, Bottled Water*

1. Introduction

Consumer desires and satisfaction are things that must be fulfilled by every industry [1]. High expectations from consumers and the level of product conformity must be comparable to the quality and standards set by the industry [2] [3]. Therefore, quality control is needed to determine the level of product defects produced and the efforts that should be made to improve the quality of the product [4] [5]. Bottled water is a product that is always sought after by the public because water is a primary human need [6]. Therefore, companies are required to always carry out quality control so that the company maintains its existence [7].

One of the companies engaged in the production of bottled water is PT. Oasis Waters International. This company operates in the field of water production in various packages ranging from 240-ml cup packaging, 600-ml bottle packaging, to 19-gallon packaging. From the results of observations that have been made at this company, there are still defective products in 240 ml of bottled water. There are several defects, such as insufficient water volume, foreign objects entering the packaging, inner rejecting cups, outer rejecting cups, and even broken cups. It can be seen from the existing data that every time a 240-ml cup of bottled water is produced, the calculation results show that at least 2% of defects occur.

In efforts to improve quality, there are many ways that companies can do to improve their quality [8]. According to [9] quality control is a technique and activity/planned action carried out to achieve, maintain and improve the quality of a product and service so that it conforms to predetermined standards and can meet consumer satisfaction. One method that companies can use to improve their quality is the Statistical Quality Control (SQC) method [10]. Statistical Quality Control (SQC) allows us to calculate the control quality of defective or non-defective products that have been produced [11].

This research aims to determine the level of defects that occur, especially in 240 ml cup bottled water, analyze the factors causing defects and describe improvement efforts that can be made at PT. Oasis Waters International to minimize the number of defective products.

2. Methods

The research was conducted at Oasis Waters International, located in Palembang City, South Sumatra. This research uses primary and secondary data types, where primary data is obtained by methods of interviews, observations and documentation. For secondary Data obtains with documents, records and literature studies relevant to the issues raised in this research. In data analysis and processing the method used refers to the method of Statistical Quality Control (SQC), using the approach of quantitative method wherein in this study carried out 4 stages [12] namely: the first stage of the examination using the check sheet done by a quality control, the second stage is calculating with the control map, the third stage is the identification of the defective product using the Pareto diagram (Pareto Analysis) [13] and the fourth stage is problem solving with the analysis of the cause-effect diagram.

3. Result and Discussion

Statistical quality control is a technique for solving problems by monitoring, controlling, analysing, managing and improving products using existing statistical methods [14] [15]. PT Oasis Waters International produces a wide range of water packaging including a 19 litre gallon packaging, 600 ml bottled water and water with a 240 ml cup packaging. The focus of this research is on the defective product on the 240 ml cup packaging water. Common types of defects such as a insufficient water volume, unkown objects, inner cup reject, outer cup reject and broken cups.

3.1. Check Sheet

The initial stage of this data processing is the collection of data such as the number of defective products, the amount of production, the type of defects as well as the amount.

Table 3.1 Product data for water defects in 240ml cup packaging

No	Date	Unknown objects	Insufficient water volume	Outer cup reject	Inner cup reject	Broken cup	Total
1	01/05/2023	0	0	0	0	0	0
2	02/05/2023	61	85	928	535	112	1721
3	03/05/2023	72	70	937	514	80	1673
4	04/05/2023	77	74	901	462	111	1625
5	05/05/2023	66	69	816	455	113	1519
6	06/05/2023	73	55	854	498	115	1595
7	07/05/2023	0	0	0	0	0	0
8	08/05/2023	59	84	840	616	78	1677

No	Date	Unknown objects	Insufficient water volume	Outer cup reject	Inner cup reject	Broken cup	Total
9	09/05/2023	75	62	673	676	88	1574
10	10/05/2023	66	61	608	557	82	1374
11	11/05/2023	60	55	718	475	100	1408
12	12/05/2023	61	99	419	584	88	1251
13	13/05/2023	53	32	774	291	84	1234
14	14/05/2023	0	0	0	0	0	0
15	15/05/2023	71	46	823	425	91	1456
16	16/05/2023	80	55	808	353	86	1382
17	17/05/2023	59	37	721	352	106	1275
18	18/05/2023	0	0	0	0	0	0
19	19/05/2023	67	43	864	294	99	1367
20	20/05/2023	22	24	227	235	50	558
21	21/05/2023	0	0	0	0	0	0
22	22/05/2023	60	93	979	529	90	1751
23	23/05/2023	39	64	660	200	66	1029
24	24/05/2023	42	41	398	290	54	825
25	25/05/2023	59	70	968	575	101	1773
26	26/05/2023	42	28	266	184	83	603
27	27/05/2023	23	199	229	262	46	759
28	28/05/2023	0	0	0	0	0	0
29	29/05/2023	54	42	693	309	84	1182
30	30/05/2023	53	62	801	328	88	1332
31	31/05/2023	44	32	582	208	71	937
Total		**1438**	**1582**	**17487**	**10207**	**2166**	**32880**

From the data obtained during one month of observation, the data that was not produced for a few days was obtaining on the date 01, 07, 14, 18, 21, 28 May 2023. The reasons for not carrying out production include national holidays and machines experiencing problems.

3.2. Control Chart

The control chart is used to monitor or monitor the stability of a process and to study changes in the process over time. In this control chart some calculations are done like

a. Calculate the ratio of error on each sample

$$Ui = \frac{\mathrm{np}}{\mathrm{n}}$$

Where np is number of failures in sub-groups and n is amount checked in the subgroup.

b. Calculate central line

To calculate the center line can be done with the following formula:

$$\mathrm{CL} = \frac{\sum np}{\sum \mathrm{n}}$$

Where $\sum np$ is total quantity of defective product and $\sum \mathrm{n}$ is total production quantity.

c. Calculate the upper control limit

To calculate upper Control limit can be done with the formula as follows:

$$UCL = CL + 3\sqrt{\frac{\text{p} \times (1-\text{p})}{\text{n}}}$$

Where p is CL value and n is number of days in production

d. Calculte the lower control limit

To calculate the lower control limit can be done with the formula below:

$$UCL = CL - 3\sqrt{\frac{\text{p} \times (1-\text{p})}{\text{n}}}$$

The control chart needs to be calculated to see the ratio of error, CL, UCL, LCL for each period. There are five types of defects in the production of 240ml cup water, so each defect needs to be calculated to monitor or monitor the stability of a process.

1. Unknown objects

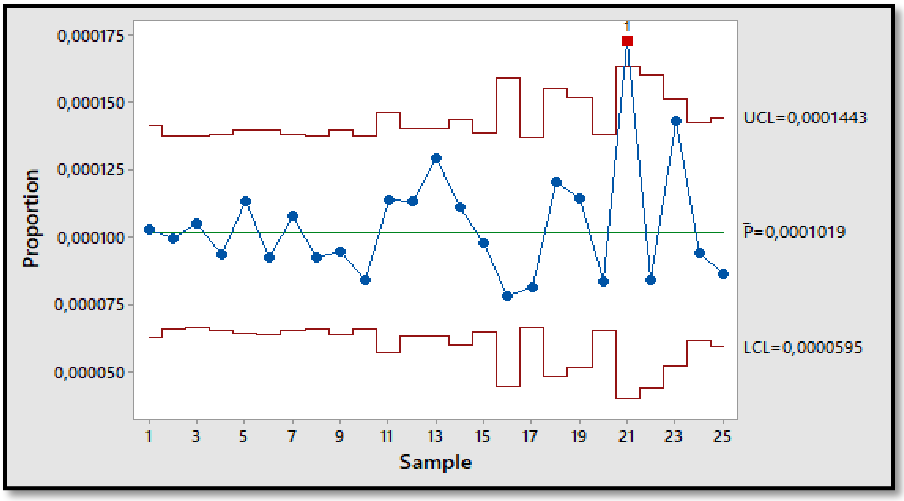

Figure 3.1 Control chart of unknown objects

From figure 3.1 the results were obtained that on May 22, 2023 it passed the upper control limit (UCL). Then it can be concluded that for quality control on the defects of this unknown object is not optimal because there are still results that go beyond the top control limit.

2. insufficint water volume

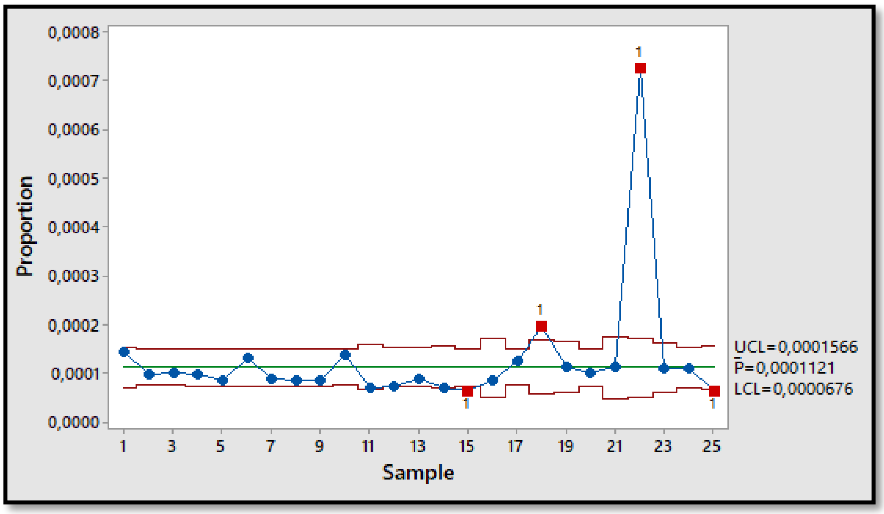

Figure 3.2 Control chart of insufficient water volume

From figure 3.2, it can be seen that there are four points that cross the upper and lower limits. For those who cross the lower limit is dated 15 and 25 May. Whereas those who pass the top limit is on 18 and 22 May. It can be concluded that the quality control for defects on the part of the volume of insufficient water has not worked perfectly and needs evaluation to reduce the defect on the type of defect insufficient water volume.

3. Outer cup reject

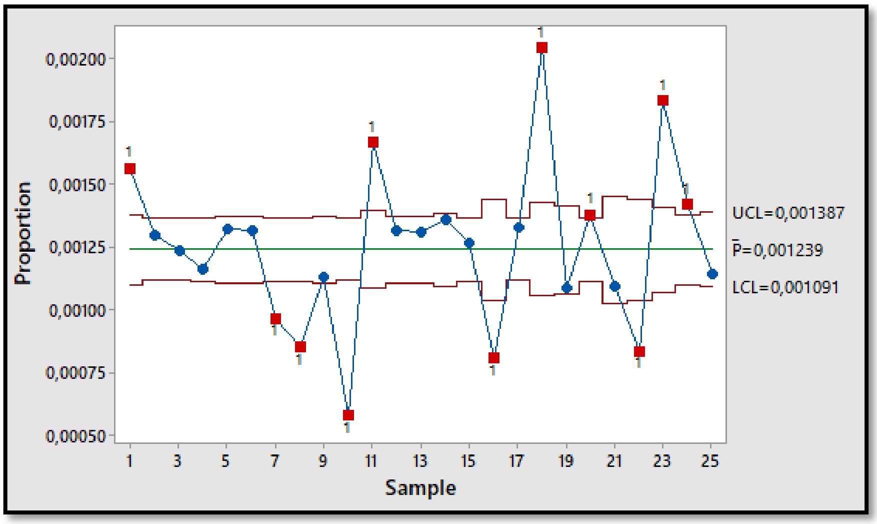

Figure 3.3 Control chart of outer cup reject

From the available results, it can be seen that there are a lot of data that crosses the upper and lower boundaries of this type of outer cup reject defect. There are five points that cross the bottom boundary and six points that go through the top limit. It can be concluded that the defect on this outer cup reject is very uncontrollable. Then it is imperative to repair the defect on the type of outer cup reject defect.

4. Inner cup reject

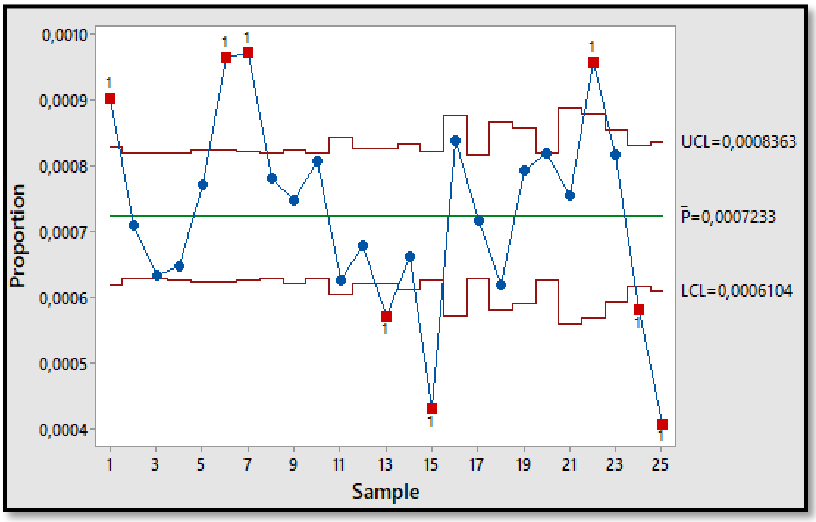

Figure 3.4 Control chart of inner cup reject

From the results of the control chart on the type of defect inner cup reject, it can be concluded that the defect on this reject has not been properly controlled. It can be seen from the chart above that there are still some points that go beyond the upper and lower boundaries.

5. Broken cup

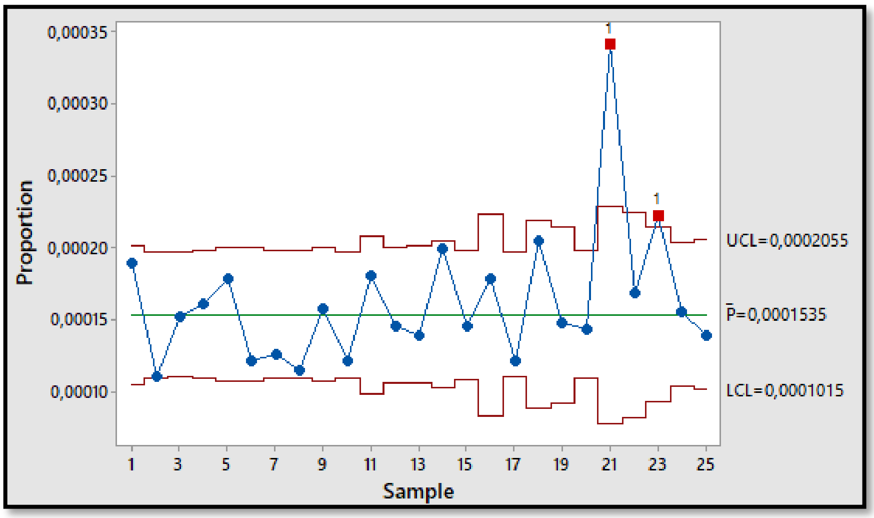

Figure 3.5 Control chart of broken cup

It can be seen that the control chart result for broken cup is not stable because there are still points that cross the upper limit (UCL). Even though only two points exceed the top limit, controls for broken cup reject are still not maximized. Because basically a control chart is said to be controlled if no data exceeds the top and bottom limits.

3.3. Histogram

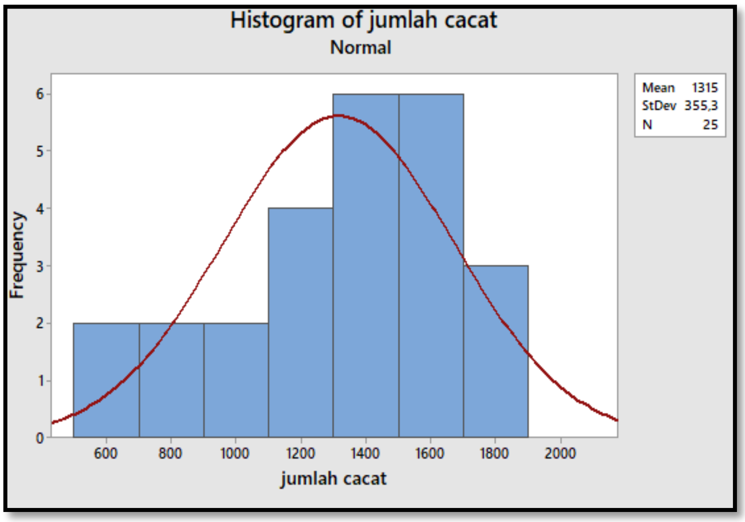

Figure 3.6 Histogram

3.4. Pareto chart

It can be seen from Figure 3.7 that defects in outer reject cups are defects with the highest percentage. Therefore, this type of outer cup defect is highly prioritized to do re-control to reduce the defective product for future processes.

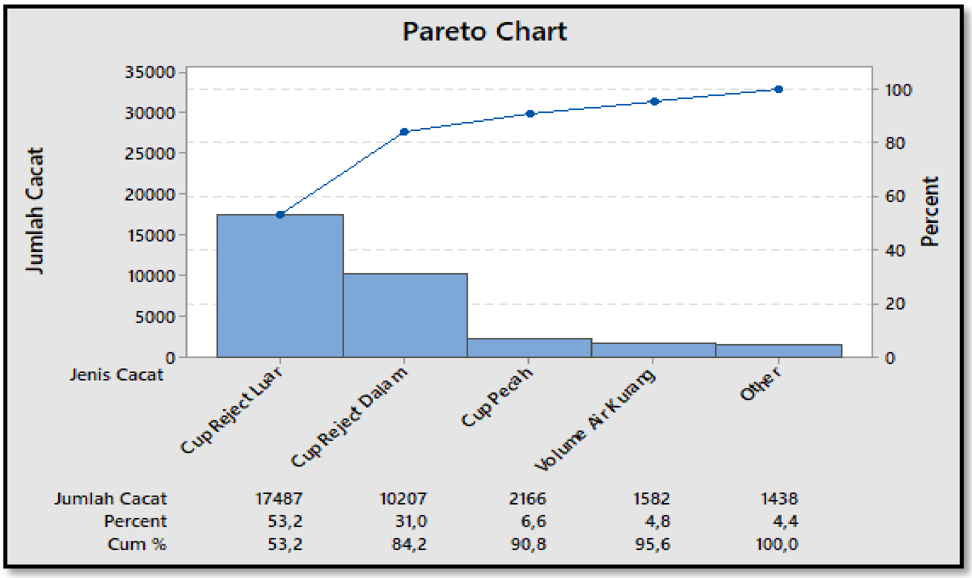

Figure 3.7 Pareto chart

3.5. Cause and effect diagram

The cause and effect diagram is used to analyze the factors that cause product damage. The factors that influence and cause product damage in general include humans, machines, methods, environment, measurement. The following is the cause and effect diagram for each defect:

1. Unknown objects

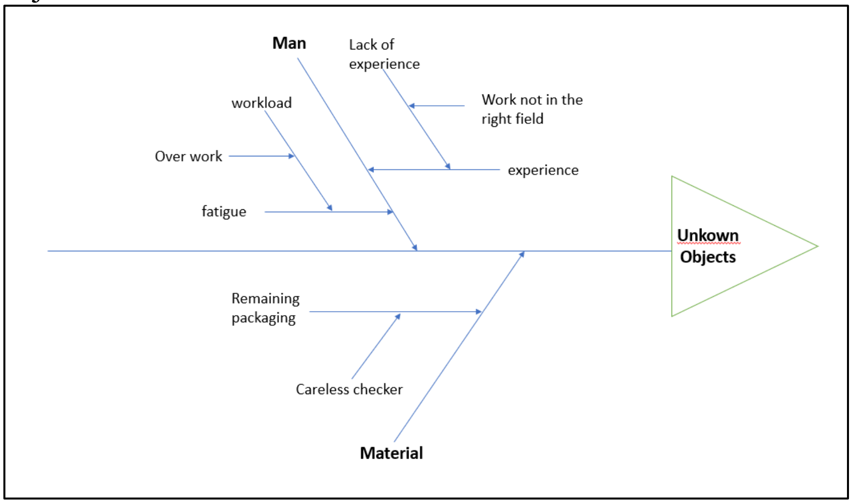

Figure 3.8 Cause and effect diagram of unkown object

2. insufficinet water volume

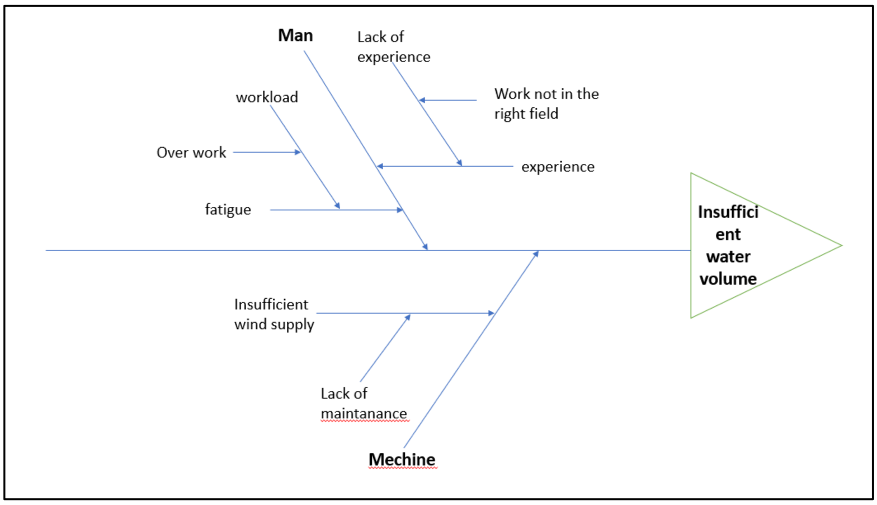

Figure 3.9 Cause and effect diagram of unsufficient water volume

3. Outer cup reject

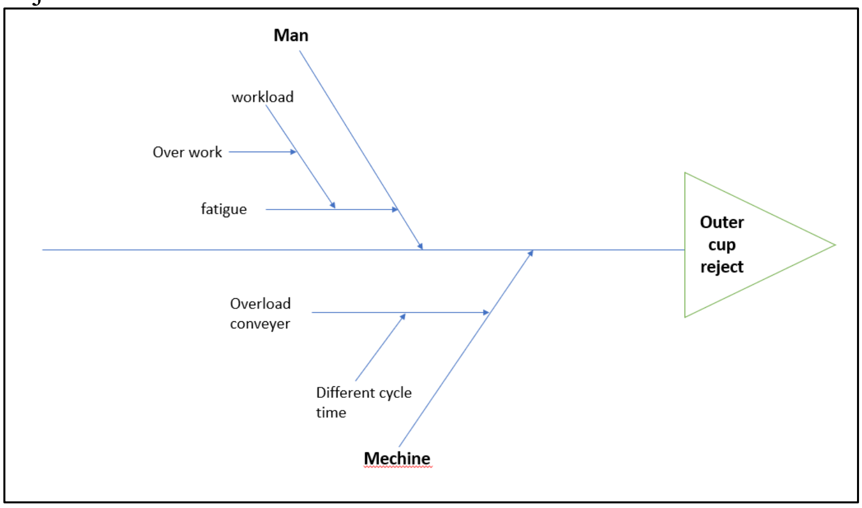

Figure 3.10 Cause and effect diagram of outer cup reject

4. Inner cup reject

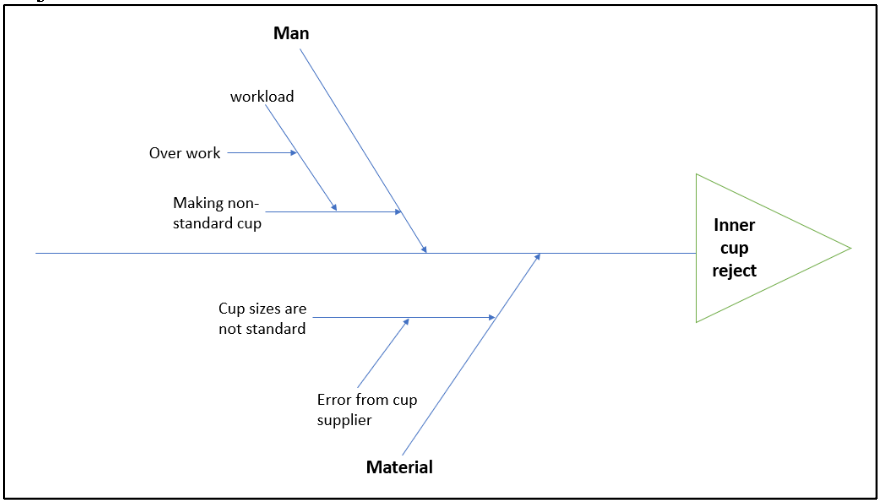

Figure 3.11 Cause and effect diagram of inner cup reject

5. Broken cup

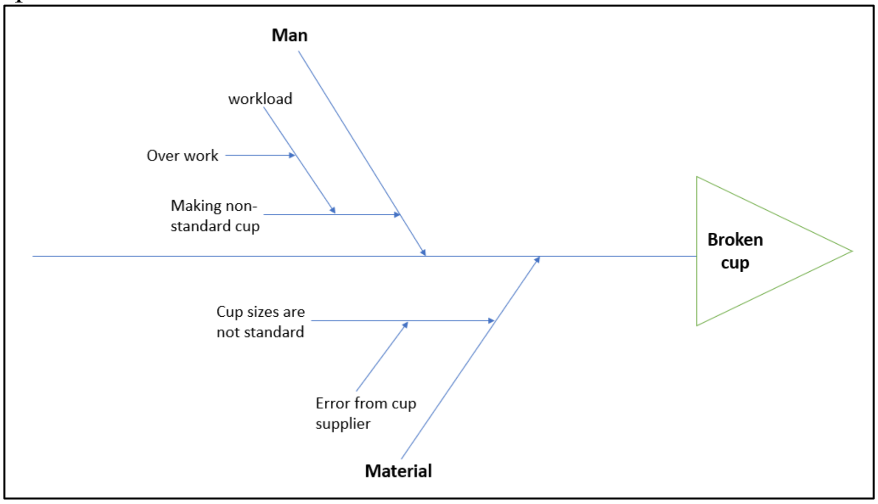

Figure 3.12 Cause and effect diagram of broken cup

A cause and effect diagram is a diagram that contains information about the factors that cause products to often be defective during production. From the results of direct field observations, we obtained various kinds of information on factors that often cause disability, such as:

a. Man, the factor that defects often occur during production is from the human perspective. These human factors cause defects during production, such as excessive workload which causes reduced performance and the experience of the workers which is one of the causes of defects in the production of 240 ml cup bottled water.
b. Material, this factor is the cause of unkown object defects and inner cup rejection. Because the materials in this raw material, such as cardboard and plastic, often enter the cup. That's why materials are said to be a factor in defects during production. As well as inner cup reject defects due to cup sizes that do not comply with existing standards, the production of 240 ml cup bottled water is not optimal.

c. Machine, also known as a factor that causes defects during production. Machines are also said to be the cause of production defects because trouble or problems in the machines cause production to be not optimal.

4. Conclusions

From the results and analysis that have been carried out using the Statistical Quality Control (SQC) method at PT Oasis Waters International, it was concluded that in the 240 ml cup bottled water production process there were five types of product defects, including unknown objects, insufficient water volume, outer cup rejection., inner cup rejection and broken cup. The percentage of defects in the type of unknown object defect was 4.37%, insufficient water volume was 4.81%, outer cup reject was 53.18%, inner cup reject was 31.04% and the last defect was broken cup with a defect percentage of 6.59% . From the results of the analysis, suggestions for improvement are obtained for each defect that occurs, such as unknown object defects. The suggestion for improvement is that it needs to be rechecked before carrying out the production process. Defects in the water volume are insufficient with the suggestion of checking the machine before production, defects in the outer reject cup with the proposed placement of visual control which is moved forward near the conveyor where there is buildup, defects in the inner reject cup with the proposed improvement must check the size first if the cup is the appropriate size standard then the new cup is suitable for the production process, defects in the cup are broken with suggestions for improvement by contacting the supplier regarding the quality of the cup received.

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