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WASTE MINIMISATION ON PRODUCTION PROCESSES OF BOTTLED DRINKING WATER USING GREEN LEAN SIX SIGMA APPROACH

MINIMASI WASTE PADA PROSES PRODUKSI AIR MINUM DALAM KEMASAN MENGGUNAKAN PENDEKATAN GREEN LEAN SIX SIGMA

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ABSTRAK

PT Baros adalah perusahaan yang memproduksi air minum dalam kemasan yang dalam proses produksinya terdapat cacat produk yang diakibatkan adanya waste sehingga terjadi limbah yang dihasilkan dari produk cacat tersebut. Tujuan penelitian ini adalah menentukan waste, menghitung nilai DPMO dan nilai sigma, menentukan penyebab dominan rijek produk, mengusulkan perbaikan pada proses produksi, dan mengusulkan untuk mengurangi potensi penyebab cacat pada produk air minum dalam kemasan cup 240 mL. Pendekatan Green Lean Six Sigma digunakan pada penelitian ini. Hasil penelitian, didapatkam waste tertinggi adalah waste defect. Tingkat sigma yang dicapai PT Baros 4,141 dengan nilai DPMO sebesar 4133,920. Berdasarkan diagram pareto diperoleh Critical to Quality (CTQ) yaitu bocor lid, lid miring, dan cup penyok. Kemudian dengan metode FMEA diketahui faktor penyebab ketiga jenis cacat tersebut. Perbaikan yang diusulkan untuk mengatasi limbah yang dihasilkan antara lain dengan cara perusahaan melakukan kegiatan bersama-sama untuk membersihkan genangan air, serta menjual cup yang sudah tidak terpakai ke pemulung, sedangkan perbaikan proses produksi dengan mengurangi dan memperbaiki kegiatan yang termasuk waste. Mengurangi potensi kegagalan produksi diusulkan dengan cara memperbaiki bucket dan melakukan pemeliharaan, inspeksi bahan baku dari supplier, complain pada supplier, melakukan komunikasi yang baik dengan supplier terkait spesifikasi bahan baku, membuat SOP pemindahan material, meningkatkan pengawasan terhadap kinerja karyawan, dan memberi teguran pada pekerja yang kurang disiplin.

Kata kunci : CTQ, DPMO, FMEA, Waste

ABSTRACT

PT Baros is a company that produces bottled drinking water in which in the production process there are product defects which are caused by waste so that waste is generated from the product defects. The objectives of this study were to determine waste, calculate the DPMO value and sigma value, determine the dominant cause of rejected product, propose improvements to the production process, and propose to reduce the potential causes of defects in drinking water products in 240 mL cup packaging. The Green Lean Six Sigma approach is used in this study. The results of the study, it was found that the highest waste was defect waste. The level of sigma achieved by PT Baros was 4.141 with a DPMO value of 4,133.920. Based on the Pareto diagram, Critical to Quality (CTQ) was obtained, namely leaking lid, tilted lid, and dented cup. Then the FMEA method is known to cause the three types of defects. The proposed improvements to overcome the waste generated included the company doing joint activities to clean up puddles, and selling unused cups to scavengers, while improving the production process by reducing and improving activities that include waste. Reducing potential production failures was proposed by repairing buckets and carrying out maintenance, inspection of raw materials from suppliers, complaints to suppliers, good communication with suppliers regarding raw material specifications, making SOPs for material transfer, increasing supervision of employee performance, and giving warnings to less disciplined workers.

Keywords : CTQ, DPMO, FMEA, Waste

INTRODUCTION

Drinking water is one of the basic human needs because if water needs are not met, it will have an impact on human survival. As technology develops, the supply of d rinking water is also growing. As an example, the provision of bottled drinking water. With many bottled water companies being built, it creates intense competition between producers. Along with the very rapid development, now beverage entrepreneurs must be extra careful (Syamsul, 2010). Consumers will select bottled drinking water that has better quality and a price that is in accordance with the quality of the product and the benefits obtained when consuming drinking water (Ningsih *et al.*, 2016).

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However, current developments are not only pay attention to the quality of goods. More issues arise the environment increasingly encourages consumers to participate preserve the environment. This makes consumers too requires producers to take part in doing the same thing, preserve the environment. Manufacturers will also look for ways so that they can then filter desires of consumers and environment. With the large number of defects that occur, there are indications of the magnitude of environmental impacts that occur in the company's production process (Arifin and Supriyanto, 2012).

PT Baros is one of the companies in Banten that produces Bottled Drinking Water. PT Banyu Reverse Osmosis or so-called PT BAROS located in District Baros, Serang Banten. This company produces bottled water in gallons of 19 L, bottles of 600 mL and 240 mL cup with the trademark: Air Baros, Wonka and Amitra. In the process of producing drinking water in 240 mL cup packaging, waste is still often found, namely overproduction, waiting, excessive inventory, transportation, process mismatches, unnecessary movements, and product defects. Waste that often occurs is waste of product defects. Based on production data in 2020, drinking water products in the 240 mL cup experienced defects 451, 344 pcs of total production produced at 21,819,648 pcs.

In addition, the defects in the resulting product will have an impact on the environment, because some types of product defects such as defects in leaky lid and dirty defects will be separated and then reopened and the water in it is discharged into the shelter which is then drained into the gutter. This causes liquid waste and solid waste.

Based on the problems that occurred at PT Baros, researchers used the green lean six sigma approach to obtain solutions to these problems. Lean six sigma approach combined with environmental management will produce green lean six sigma which can eliminate waste and minimize defects and measure impact the environment of the production process that occurs (Gasperzs, 2007). However, according to Raymond (2009) six sigma green lean applications can only measure environmental impact but can also be applied to overcome energy usage problems, problems in terms of packaging and logistics, and solid waste to achieve optimal performance.

This research aims to assign the waste that happen in the production process of drinking water in 240 mL glass packaging, determine the DPMO value and sigma level, assign the dominant factors causing defect waste, determine the waste generated due to product rejects, propose improvements to the production process, and calculate the value of Process Cycle Efficiency (PCE) initial conditions and proposed improvements.

The following is the theory and understanding of the method used in this study, including about quality. Quality can be defined as conformity to market needs or suitability of product use to meet customer needs and satisfaction (Amrina and Fajrah, 2015). While the definition of the Green concept includes the process of making products that minimize negative impacts on the environment, are safe for employees, communities and consumers, save energy and natural resources, and still have economic value. (Dornfeld, 2014). The definition of Lean is a continuous effort to identify and reduce activities that do not have added value in the production process, and manage supply chains that are directly related to customers and to add the added value of products.

In this study, Value Stream Mapping will be carried out, which is a mapping method in the form of an overview of the production process flow from the beginning of the staple coming from the supplier to the product to the user, made in detail to identify and eliminate waste that occurs, and provide improvements to the production flow process (Ridwan *et al.*, 2018). Data processing in this study uses a Six Sigma approach with the step of define, measure, analyze, and improve. (Ulfah *et al.*, 2021). Six Sigma is a sustainable effort to generate process variation, so that increase process capability in producing an error-free product (goods or service) with the smallest target of 3.4 Defects Per Million Opportunities (DPMO) and provide value to customers (Hutahean, 2018). While Lean Six Sigma is a composition of Lean and Six Sigma which can be interpreted as a business philosophy, systemic and systematic approach to identify and reduce waste or Non-Value Added activities through sustainable improvement to reach Six Sigma performance levels by only producing 3.4 Defects Per One Million Opportunities or operations, a lean six sigma approach combined with environmental management will result in green lean six sigma to reduce waste and minimize defects and measure the environmental impact of the production process. (Gaspersz, 2007). The FMEA method is used to identify and prevent failure modes and identify the root causes of quality problems. (Ulfah *et al.*, 2019]. FMEA is an engineering technique used to assign, identify, and reduce failures, problems, errors, and the like from a system, planning, process and or service before it reaches the consumer (Hanif *et al.*, 2015). The FMEA method is suggested to analyze the consequences of a process and its effect on the corporation (Fitriana *et al.*, 2020). The advantage of FMEA is that it can evaluate reliability by examining failure modes and one of the systematic techniques for analyzing failures (Ulfah *et al.*, 2016).

RESEARCH AND METHOD

In this research consists of two stages, namely the first stage of the observation and study of literature and data collection, and the second stage is the methodology of Green lean six sigma.

Stage 1 : Observation, study literature and data collection.

In the first stage, it is divided into 3 steps, namely observation and literature study, primary data collection and secondary data collection. The first stage begins with field observations and literature studies. At this stage, research and direct observation are carried out to identify problems that exist in the company and study some literature about the methods used as a reference in overcoming problems that exist in the company.

Stage 2 : Problem Solving Stage

Methodology of Green lean six sigma

The Lean six sigma stage consists of five stages which are often shortened to the DMAIC cycle (Define, Measure, Analyze, Improve and Control). This step is to assign an action plan that must be carried out to make improvements at each stage of the proceproduction process. The next step is define, measure, analyze, and improve.

At the define step, data processing is carried out, namely identification of observed products, critical to quality (CTQ), SIPOC diagrams, identification of waste, process activity mapping, identification of production process activities, current state Value Stream Mapping, and identification of environmental impacts. Product identification is carried out to assign the type of bottled drinking water product that has the highest number of defective products. Furthermore, critical to quality (CTQ) to assign the type of product defect that most dominantly occurs. The next step is to create a SIPOC diagram to describe the general business process flow. SIPOC diagrams depict business flows from suppliers, inputs, processes, outputs, and customers. After making the SIPOC diagram, the next step is to identify waste based on the results of the seven waste questionnaire that has been filled out by four respondents to determine the type of waste that is the most prioritized then make a process activity mapping to determine the flow of bottled drinking water production process activities which are then mapped using Value Stream Mapping to find out the type of activity. The next step is the identification of environmental impacts that are useful for knowing what environmental impacts arise due to defects in drinking water products in 240 mL glass packaging.

Measure

Measure stage is the stage of measuring sigma level, calculating process cycle efficiency, making Pareto diagrams, P control charts, calculating DPMO and sigma levels, and calculating total waste. The calculation of PCE is used to measure the efficiency of the activity of the bottled drinking water production process in 240 mL cup. The next step is to make a Pareto Diagram to assign the most dominant type of defect. P control chart calculations were carried out on defect data for bottled drinking water products in 240 mL cup to find out which parts were rejected because they did not meet specifications, as well as to assign whether the control of the production process was good or not, the next step is the calculation of DPMO and sigma level which is carried out to measure the company's performance based on the obtained sigma level. Calculation of DPMO and sigma value is carried out based on the determination of CTQ, then total waste is calculated to find out the total waste that arises due to defects in products of bottled drinking water in 240 mL cup.

Analyze

The analyze step is carried out to analyze the causes of the dominant type of defect. At this stage using fishbone diagram tools and Failure Mode and Effect Analysis (FMEA). Fishbone diagrams are used to find the root cause of the problem of defects in products of bottled drinking water in 240 mL cup and the waste generated due to defective products based on human factors, machines, and methods. Then the results from the fishbone diagram are analyzed using Failure Mode and Effect Analysis (FMEA) and the Risk Priority Number (RPN) value is obtained.

Improve

At the improve stage, suggestions for improvements will be made regarding product quality and flow efficiency of the bottled drinking water production process in 240 mL cup. The proposed improvement is carried out using the recommended action planning FMEA to get a proposed improvement based on the priority causes of product defects, then make a future state Value Stream Mapping to determine the efficiency of the production process flow after eliminating and reduction in Non-Value-Added but important and Non-Value-Added activities, then compare the initial conditions with after the improvement based on the process cycle mapping indicator and the total waste generated.

This research was carried out only up to the improve stage in the DMAIC cycle.

Methodology of Failure Mode and Effect Analysis (FMEA)

Problem solving FMEA begins with conducting interviews with related parties. Interviews were conducted with the production division and quality control division to identify process failures that cause defective products, then fill in the mode of failure. At this stage it is done to describe the way in which a product or process fails to carry out the required function, followed by filling in the cause of failure, this stage is done to fill in what causes failure in the bottled drinking water production processing 240 mL cups then fill in the effect of failure which is filling in the impact or consequences if the component fails as stated in the potential failure mode. There are 3 weights that are included in giving a score, namely the occurrence, severity and detection values. Occurrence is how often the specific cause of failure of a project will occur. Occurrence is shown on 10 levels from almost never, namely a scale of 1 to the most likely to occur or difficult to avoid, which is a scale of 10. Severity value is how serious the condition is if a failure occurs. Detection value is the degree of probability of escaping the cause of the failure of the installed control (detected or not). The next step is to calculate the rank priority number (RPN) by multiplying each weight from the Occurrence (O), Severity (S), and Detection values (D).

$$RPN = O \times S \times D \quad (1)$$

RPN numbers range from 1 to 1000, where the higher the RPN value, the riskier the process is to produce a product with the desired specifications. After obtaining the RPN value, then determining the RPN rank from the largest value to the smallest value.

RESULT AND DISCUSSION

Define Stage

Identification of Critical to Quality (CTQ)

Identification of waste in the production process of bottled drinking water in 240 mL cup is done by filling out the seven waste questionnaire. The questionnaire was given to four respondents who have experience and are responsible for the on going production process at PT Banyu Reverse Osmosis. The following is a recapitulation of the research questionnaire consisting of four respondents from PT Banyu Reverse Osmosis, namely.

From the results of the calculation of the weight of each waste, the waste that occurs most often is defect waste, so that defect waste becomes the most priority waste to be followed up. As for the waste defect referred to in this study is a defect in the finished product that is not up to standard. Based on the critical to quality (CTQ) of the product, found 5 types of CTQ in 240 mL cup of products bottled drinking water, namely defects in leaky lid, oblique lid, dent cup, volume do not match specifications, and dirty water.

Identification of Waste

Stage identification of waste is done by using questionnaire. Based on the results of questionnaires can be known the results of the average weight of each waste. The type of waste over production has an average weight of 2.75, transportation for 0.25, waiting for 0.5, unnecessary inventory of 0.75, unnecessary process of 2.5, unnecessary motion of 2.25, and defects at 3.5 (as shown in table 1). The weight that has been obtained is used in the value calculation of stream mapping analysis tools by multiplying these weights with matrix multipliers in VALSAT. The biggest weight obtained in the mapping tool is process activity mapping. Mapping tools using VALSAT (Value Stream Mapping Analysis Tools) is done by multiplying the average weight value of each waste by the multiplier of the relationship between waste and VALSAT mapping tools. As for the multiplier factor, it can be seen in Table 2 below.

The following is the result of weighting the value stream mapping analysis tools from the calculation results of the seven waste questionnaire.

Calculation Example:

PAM Overproduction = weight × weighting seven waste = 2.75 × 1 = 2.75)

Total PAM Weight = PAM Over production weight + ... + PAM Defect weight = 2.75 + 2.25 + 4.5+ 2 ,25 + 22.5 + 20.25 + 3.5 = 58

Table1. Weight of waste questionnaire of bottled drinking (240 mL cups)

No.	Type of *Waste*	Weight				Total	Average	Rank
		1	2	3	4			
1.	Over production	2	3	3	3	11	2,75	2
2.	Transportation	0	1	0	0	1	0,25	7
3.	Waiting	1	0	1	0	2	0,5	6
4.	Unnecessary Inventory	1	0	1	1	3	0,75	5
5.	Unnecessary Processing	3	3	2	2	10	2,5	3
6.	Unnecessary Motion	2	2	2	3	9	2,25	4
7.	Defect	3	4	3	4	14	3,5	1
	Total	12	13	12	13	50	12,5	

(Source: PT BAROS, 2019)

Tabel 2. Value stream mapping tools

Type Waste	Mapping Tools						
	Process Activity Mapping (PAM)	**Supply Chain Response Matrix (SCRM)**	**Production Variety Funnel (PVS)**	**Quality Filter Mapping (QFM)**	**Demand Amplification Mapping (DAM)**	**Decision Point Analysis (DPA)**	**Physical Structure (PS)**
Overproduction	L	M		L	M	M	
Transportation	H						L
Waiting	H	H	L		M	M	
Unnecessary inventory	M	H	M		H	M	L
Unnecessary processing	H		M	L		L	
Unnecessary motion	H	L					
Defect	L			H			

(source: Hines and Rich, 1997)
Description :
H (High correlation and usefulness) : multiplier = 9
M (Medium correlation and usefulness) : multiplier = 3
L (Low correlation and usefulness) : multiplier = 1

Tabel 3. Value Stream Mapping Analysis Tools (VALSAT)

Waste	Bobot	Mapping Tools						
		PAM	**SCRM**	**PRV**	**QFM**	**DAM**	**DPA**	**PS**
Over production	2.75	2.75	8.25	0	2.75	8.25	8.25	0
Transportation	0.25	2.25	0	0	0	0	0	0.25
Waiting	0.5	4.5	4.5	0.5	0	1.5	1.5	0
Unnecessary Inventory	0.75	2.25	6.75	2.25	0	6.75	2.25	0.75
Unnecessary Processing	2.5	22.5	0	7.5	2.5	0	2.5	0
Unnecessary Motion	2.25	20.25	2.25	0	20.25	0	0	0
Defect	3.5	3.5	0	0	31.5	31.5	0	0
Total	12.5	58	21.75	10.25	57	48	14.5	1

(source: PT BAROS, 2019)

Tabel 4. Persentage of production activity time grouping

No	Activity Group	Activity	Processing Time (detik)	User of Time (5)
1.	Value Added	19	1.590	68,594
2.	Necessary Non Value Added	21	698	30,112
3.	Non Value Added	1	30	1,294
Total			2.318	100

In table 3, it can be seen the value of each mapping tool. The highest score is the activity mapping process mapping tool (PAM), which is 58. The basic concept of this instrument is to map each step of activity that occurs starting from operation, transportation, inspection, delay, and storage, then grouping them into existing types of activities ranging from value added activities (VA), necessary non-value added activities (NNVA).) and non value added activities (NVA).

Identification Of Production Activities

Identification activities of the production process used to identify and classify the activities that fall into the category of Value Added (VA), Necessary Non-Value Added (NNVA) and Non-Value Added (NVA). There are 19 activities in the production process of drinking water in 240 ml cups which are included in the Value Added (VA) activity with a total activity time of 1,590 seconds, which is included in the Necessary Non Value Added (NNVA) activity, there are 21 activities with a total activity time of 698 seconds, while there is 1 activity, namely Cup and Lid rolls waiting to be placed in the machine with a time of 30 seconds, this activity includes Non-Value Added (NVA) activities, namely activities that do not add value to a product being processed. This activity can be reduced or eliminated, because this activity is pure waste which is very detrimental. From the results of the identification of Value Added (VA), necessary non value added (NNVA), and non value added (NVA) activities, the total production time of bottled drinking water in 240 mL cup at PT Banyu Reverse Osmosis can be grouped as follows In the Table 4.

In the Table 4 above, it can be seen that the lead time of the production process of bottled drinking water in 240 ml cups is 2,318 seconds. The percentage of time used for value added activities is 68.594%, necessary non value added is 30.112%, and Non Value Added is 1.294%.The Lead time of the process of producing bottled drinking water in a cup of 240 ml is equal to 2,318 seconds. The percentage of the use of value added activity that is equal to 68.594 %, necessary non value added is 30.112 %, and non value added is 1.294%.

Environmental Impact Identification

Identification of environmental impacts is carried out to assign whether the drinking water production process has a good or bad impact on the surrounding environment. The results of interviews with the company, defective products leaked the lid and dirty water will be separated, then the packaging is opened again and the water will be discharged into the gutter. The process produces the impact of liquid waste (39,624,480 mL) and solid waste (165,102 pcs). Waste water produced as a result of product defects drinking water in the form of water from the reject defective products are dumped into a ditch, solid waste generated in the form of waste plastic cup that was not used.

Measure Stage

Calculation of Process Cycle Efficiency (PCE)

At this stage it is done to see whether the process can be said to be efficient. The following is the Process Cycle Efficiency (PCE) calculation.

$$\text{PCE} = \frac{\text{Total } \textit{Value Added Time}}{\text{Total } \textit{Lead Time}} \times 100\ \%$$

$$= \frac{1{,}590}{2{,}318} \times 100\ \% = 68.594$$

Based on the results of calculation, it can be t the process cycle efficiency (PCE) of bottled drinking water production in 240 ml cup is 68.594 %.

Pareto Diagram

In Figure 1 states the defect results from the largest to the smallest. In accordance with the Pareto principle states the 80 : 20 rule which means 80 percent quality problems are caused by 20 percent of causes disability, so the types of disabilities are chosen with cumulative reaches 80% assuming that with 80% it can represent all types defects that occur (Gunawan and Clara, 2016).

In this study there were 3 types of disabilities that reached 80% cumulative, namely defects leaked lid with a percentage of 36.6%, lid oblique with a percentage of 28.3%, and dent cup defects of 20.1 %.

P-Chart

P-Chart is a chart used to observe a part that is rejected because it does not meet specifications (called a defective part). In Figure 2 , it can be seen that data passes the upper and lower control limits. This indicates that the production process has not been stable, so it needs to make improvements so that the production process becomes stable and controlled.

Calculation of DPMO and Sigma Level

Calculation of DPMO and Sigma Level is carried out to measure the company's performance, namely the work station that causes the product to be unsuitable.

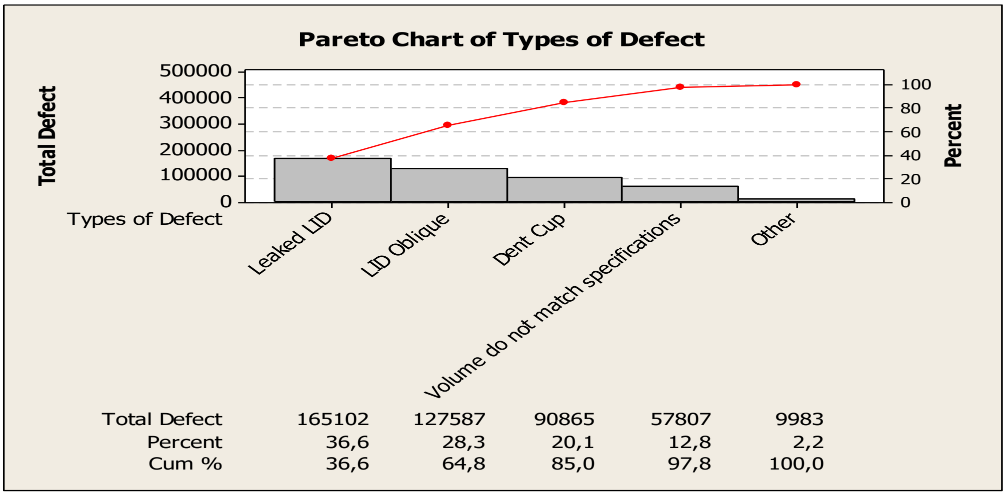

Figure 1. Pareto diagram

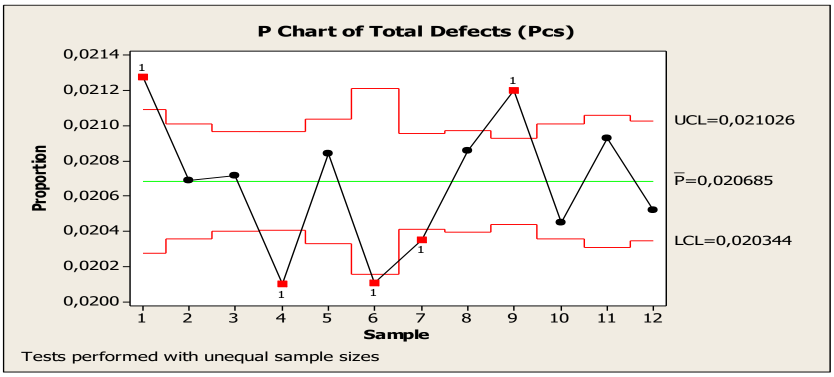

Figure 2. P-Chart

Table 5. Calculation of DPMO and level sigma

No	Month 2019	Total Production (Pcs)	Total Reject (Pcs)	CTQ	DPU	DPO	DPMO	*Sigma Values*
1.	Jan	1,098,720	23,376	5	0.0212757	0.0042551	4,255.133	4.131
2.	Feb	1,714,608	35,472	5	0.0206881	0.0041376	4,137.622	4.141
3.	March	2,284,320	47,328	5	0.0207186	0.0041437	4,143.728	4.140
4.	April	2,321,280	46,656	5	0.0200993	0.0040199	4,019.851	4.150
5.	May	1,462,656	30,480	5	0.0208388	0.0041678	4,167.761	4.138
6.	June	656,496	13,200	5	0.0201067	0.0040213	4,021.350	4.150
7.	July	2,452,848	49,920	5	0.0203519	0.0040704	4,070.370	4.146
8.	August	2,188,272	45,648	5	0.0208603	0.0041721	4,172.059	4.138
9.	Sept	3,054,624	64,752	5	0.0211980	0.0042396	4,239.605	4.132
10	Oct	1,715,664	35,088	5	0.0204516	0.0040903	4,090.311	4.145
11	Nov	1,300,560	27,216	5	0.0209264	0.0041853	4,185.274	4.137
12	Dec	1,569,600	32,208	5	0.0205199	0.0041040	4,103.976	4.143
Total		21,819,648	451,344	Average	0.0206700	0.0041340	4,133.920	4.141

Based on the Table 5, the DPMO and sigma values of each data can be known. The average DPMO value obtained is equal to 4,133.920 and produces an average sigma value of 4.141. Furthermore, to find out whether the current production process has been considered capable or not, it is necessary to calculate the process capability index (Cp). The following is a calculation of the process capability index in drinking water products in a 240 mL cup packaging:

$$\text{Sigma level} = Cp \times 3 \quad Cp = \frac{\text{Level } Sigma}{3}$$

$$= \frac{4.141}{3} = 1.380$$

From the calculation of the process capability index value above, the Cp value is 1.380. According to Aldiandru (Aldiandru, 2017), the value of Cp < 2, then the production process still needs continuous improvement to reach the target of 6- sigma (Cp = 2).

Calculation Of Total Waste

Example Calculation:

Total Water Waste= number of defective lid products (pcs) × units = 165,102 pcs × 240 mL = 39,624,480 mL ≈ 39,624.48

The financial loss from defects in drinking water products in 240 mL cup packaging can be calculated by multiplying the number of defective products leaked lid with the selling price per 1 pcs of drinking water in a 240 mL cup packaging . In this study, the selling price per 1 pcs of drinking water in a 240 mL cup is IDR 222.46. The following is the calculation of the potential total losses due to defects in leaking lid:

Total loss potential = The number of defective products leaked lid × selling price per 1 pcs = 65,102 × IDR 222.46 = IDR 36,728,590.92

The following is a Table 6 of total waste produced due to defects in leaking lid.

Table 6. Total waste

Types of waste	Total Leaking Lid (Pcs)	Satuan	Total
Water *Cup*	165,102	240 mL Pcs	39,624,480 mL 165,102 pcs

From the calculation above, it can be seen that the total potential loss that will be experienced by the company due to product defects due to leakage of the lid is IDR 36,728,590.92.

Analyze Stage

Fishbone Diagram

At this stage, the root cause of each type of defect is obtained.The root cause of the problem with lid leaking defects is overtime, poor lid and cup quality from suppliers, defective buckets because they have not been repaired, no weekly maintenance checklists, no monthly maintenance checklists, and no updating of production SOPs. The root cause of the tilted lid defect is that the operator lacks focus, the operator lacks training, the quality of raw materials from suppliers is not good, there is no monthly maintenance checklist, and there is no SOP for setting the brake belt. The root cause of the dented cup defect is the absence of an SOP for material transfer, defects in raw materials from suppliers, and no SOP for product storage.

FMEA (Failure Mode and Effect Analysis)

At this stage, each root cause of the problem from defects in leaking lid , sloping lid , and dent cup is analyzed for potential failure. Type failure with the highest RPN value will be become a priority type of failure to be repaired. The highest RPN value is 180 with the type of failure in the form of a flawed bucket which causes a lid leak defect. The following is a summary of the FMEA Table 7 from the waste analysis.

Improve Stage

Action planning Failure Mode and Effect Analysis (FMEA)

The action planning FMEA is the advanced stage of FMEA which is used as the repair stage. In the process FMEA been obtained ranking of the results of sequencing the value of the RPN on a priority basis. Based on the results of sorting the failure mode is a priority i.e. bucket defects caused by no bucket repairs, while the recommended improvement is fixing the bucket and performing maintenance.

Proposed future state Value Stream Mapping

This stage is done by reducing the activity time and eliminate some of the activities included in the waste, while the reduced activity period ie on the type of transport activity, while activity is eliminated that kind of activity waiting. Next, make a Future State Value Stream Mapping to determine the process cycle efficiency cup 240 mL bottled water products after making repairs. Plans for the proposed improvement of NNVA activities are as follows:

Tabel 7. Failure mode and effect analysis (FMEA) of waste

Process	Mode of Failure	Cause of Failure	Effect of Failure	Occurence (1-10)	Severity (1-10)	Detection (1-10)	RPN (1-1000)	Rank
Waste water and cup	Workers are not sterile when entering the production room	Lack of discipline	The water will be contaminated with dust and dirt contained in the	5	7	4	140	3
	Lid is not up to standard (thin)	The quality of the lid from the supplier is not good.	Lid workers easily tear during the pressing process, causing product defects.	6	9	3	162	2
	Cup lip is not flat	The cup quality from the supplier is not good.	Lid does not stick to the cup, causing product defects	4	7	4	112	4
	Defective bucket	The Bucket	The lip of the cup is not held up by the bucket when pressing, causing product defects.	10	9	2	180	1
	Machine is more than 10 years old	Not yet updated the machine	Many components are damaged so that the production process is lacking maximum and still produces product defects.	9	9	1	81	5
	Operator produces when the heater is not stable	Not yet updated the production SOP.	Sticking the lid with the cup is not optimal	4	9	2	72	6

a. Eliminate cup and roll lid transportation activities into the production room by transporting cups and lid rolls directly to the machine, so that the activity time which was originally 30 seconds becomes 0 seconds.
b. Reducing the distance of transportation to temporary storage by bringing the temporary storage closer to the inspection station, so that the activity time originally from 10 seconds to 5 seconds.

Plans for the proposed improvement of NVA activities are eliminate the activity of waiting for where the cup and roll lid are waiting to be placed in the machine, therefore the recommended improvement proposal is to immediately put the cup and lid roll on the machine, so that the activity time which was originally 30 seconds becomes 0 seconds. After eliminating the activity and reducing the activity time and described in the future state value stream mapping obtained PCE proposed an improvement of 70.573%, resulting PCE 240 ml cup bottled water products increased by 1.979% from the initial conditions described by the current state value stream mapping amounted to 68.594%.

Proposed Waste Management

The results of interviews with the company, the defective 240 mL cup bottled drinking water resulted in the impact of liquid waste and solid waste. The liquid waste generated as a result of this drinking water product defect is in the form of rejected product defect water which is collected back and then disposed of into a ditch, while the solid waste generated is in the form of plastic cup waste that can no longer be used or is disposed of or collected and sold to scavengers. Company Plastic goods cannot decompose, cannot absorb water, cannot rust and cannot be decomposed (degraded) in the soil which in turn will cause problems for the environment. Plastic waste that exists today is generally disposed of at the final disposal site (TPA), burned or some of them are still suitable for recycling. However, the process is still not able. to solve all the problems related to plastic waste PT Baros is handling the waste cup less well because this company does not directly process the cup waste produced. The handling of waste carried out by the company is by collecting the cup and then selling it to scavengers which will later be collected in an agent to be processed into chopped plastic.

According to Marliani (Marliani, 2014) for waste management to take place well and achieve the desired goals, each waste management activity must follow the philosophy of waste management. The philosophy of waste management is that the less and closer the waste is managed from the source, the management will be easier and better, and the less affected environment will also be affected. Therefore, PT Baros needs to pay attention to the production process in order to minimize the amount of plastic cups that are wasted due to product defects, so that if the number of product defects decreases, the amount of waste produced will decrease and the impact on environmental pollution will decrease.

CONCLUSIONS

The happening of waste in the production process of 240 ml cup bottled drinking water at PT Baros is over production, waiting, unnecessary inventory, transportation, unnecessary processes, unnecessary movements, and defects. The priority improvement is Waste defect because it has the largest average value.

The average DPMO value obtained is equal to 4,133.920 with a sigma level on average of 4.141. The most dominant types of defects are leaking lid, oblique lid, and dent cup. The cause of the defect in the lid leak is the absence of defective bucket repairs. Lid oblique defects caused by the quality of raw materials from suppliers is not good, while the cause of the defect cup dent is no SOP material removal. The waste generated due to the defect of 240 mL cup of drinking water products at PT Baros is liquid waste and solid waste. Liquid waste itself is in the form of water that is discharged into a ditch , while the solid waste is in the form of a cup that is no longer used.

Improvements to minimize activity the production processes are suggested to eliminate cup and roll lid transportation activities to the production room by transporting the cup and lid rolls directly to the machine, reducing the time of transportation activities to temporary storage by bringing storage to the inspection station, and eliminating activities waiting. Proposed to improve to reduce potential failures are carried out by repairing buckets and carrying out maintenance, rechecking raw materials from suppliers, complaining to suppliers, communicating well with suppliers regarding raw material specifications, making SOPs for material transfer, improving employee performance monitoring, and giving warnings to workers, less disciplined.

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