Quality Control of Packaged Drinking Water (AMDK) Products
(Case Study: CV. Tirta Sasmita)

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ABSTRACT

The quality of bottled drinking water (AMDK) has now begun to decline, prompting public complaints about dirty water, bad taste, and other issues. This study aims to analyze the quality control of bottled drinking water (AMDK) products at CV. Tirta Sasmita with product defects that still frequently occur, such as incomplete water, leaks, damaged cups, bad water, machine rejects, damaged cartons, damaged lids, and to determine what factors cause these defects in the production process. The method used is the Total Quality Management (TQM) approach and the six sigma DMAIC stage (Define, Measure, Analyze, Improve, and Control) with an analysis of 220 ml AMDK production data in the period January 2024 - January 2025. The results of the study show a total production of 38,462 per unit with a number of defective products of 6,582 per unit. The dominant defect type is the leak defect, at 2,328 per cup. Analysis using a proportion control chart (p-chart) shows that most processes remain within the control limits, but several points are outside the limits, indicating instability in the production process. The main causes of defects come from machines, human resources, methods, and materials. From this study, quality control at CV. Tirta Sasmita is not yet fully stable. Therefore, the company is advised to conduct regular machine maintenance and enhance quality oversight to improve the quality of AMDK products and minimize defects.

Keywords: *Bottled drinking water quality control, Six Sigma, and quality management (TQM)*

Introduction

Water is a vital necessity for human survival, as it plays a vital role in maintaining fluid levels in the body. With rapid population growth, the need for drinking water continues to increase. However, this opportunity is not without risks. Companies must strive to compete in the marketplace. Company performance, through proper management, will generate profits through high-quality products and retain customers through optimal service. Both of these benefits can be achieved by focusing on quality. Quality is a crucial consideration and cannot be overlooked[1], [2], [3], [4].

However, this opportunity is not without risks. Companies must strive to compete in the marketplace. Company performance, through proper management, will generate profits through high-quality products and retain customers through optimal service. Both of these benefits can be achieved by focusing on quality. Quality is a crucial consideration and cannot be overlooked. This increasingly demands excellent performance from every company or industry involved[5], [6], [7].

According to [8], product quality is the overall characteristics and capabilities of a product or service in terms of its ability to satisfy specified or stated needs. The greater a company's ability to produce products that meet consumer needs, the higher the quality of the product. Quality requires a continuous improvement process that can be measured at the individual and organizational levels in aligned with company performance goals.

Product quality is influenced by the raw materials used, the production process, and the final product. Therefore, a company's activities or efforts are directed toward providing quality control for components, from inputs to the production process, including inspections, packaging, and the final product, which must be re-inspected before being ready for distribution to consumers. This ensures a truly high-quality product. Implementing these quality control activities will undoubtedly reduce the number of defective products in the production process.

Quality control is necessary within a company to minimize operational costs and ensure that products meet predetermined quality standards within a predetermined timeframe. Quality control is the activity of ensuring that quality policies (standards) are reflected in the final product. In other words, it is an effort to maintain the quality of the goods produced so that they meet the product specifications established by management policy. Good quality control will help ensure the smooth running of the production process, thereby achieving production targets [9].

Companies' quality control aims to reduce the number of defective or damaged products. The quality of bottled drinking water (AMDK) has begun to decline, with numerous public complaints about products such as dirty water and unpleasant taste[10], [11], [12].

CV Tirta Sasmita is a company engaged in the bottled drinking water (AMDK) sector. Water, the primary raw material for the product to be processed, is sourced from mountain springs in the production process. To control product quality, the company has implemented controls across the entire supply chain, from water sourcing to packaging. The goal is to ensure that the product meets established standards. In addition to packaging quality and safety, the company ensures that all product packaging information meets standards and complies with applicable laws and regulations. Although the production process undergoes a fairly stringent quality control system, some products are still defective or damaged due to a lack of consistency in the application of quality control procedures during the final inspection stage[13], [14], [15].

Research Methods

This research uses a descriptive quantitative approach, in which the data obtained are the result of systematic observation of an event. To achieve the research objectives, the researcher used improvement proposal tools with TQM and Six Sigma to control product quality. This tool aims to identify the causes of product defects and propose improvement initiatives to enhance product quality and reduce them[16], [17], [18].

The types and sources of data used to support this research include: secondary data from CV. Tirta Sasmita obtained through interviews in the quality control department and company data documentation. The following data was collected:

1. Data on the production volume of 220 ml bottled drinking water (AMDK) from January 2024 to January 2025.
2. Data on the production volume of defective 220 ml bottled drinking water from January 2024 to January 2025.
3. Data on the types of defects in 220 ml bottled drinking water from January 2024 to January 2025.

This study uses a descriptive, quantitative approach, guided by the DMAIC (Define, Measure, Analyze, Improve, Control) framework, to control the quality of bottled drinking water products.

a. Research Design
   The research was conducted through analysis of product defect data to identify dominant defect types and formulate quality improvement proposals.
b. Research Period and Location
   The research was conducted at CV. Tirta Sasmita from January 2024 to January 2025.
c. Data Source
   The data used to support this research are secondary.
d. Unit of Analysis
   The unit of analysis in this study was cup-based bottled drinking water (AMDK) products that experienced production defects.
e. Data Analysis Technique
   - Check sheet: recording the number and type of defects
   - Pareto diagram: determining dominant defects
   - P-chart: controlling the proportion of defects
   - Fishbone diagram: determining the root cause of defect analysis
   - DPMO and sigma levels: measuring quality performance
   - Improvement -control plan: formulating and controlling improvements.

   The main factors that cause defective products can help in:

   a. *Material*
      - Low-quality lids
      - Cups are not precise
   b. *Machine*
      - Unstable sealing temperature
      - Insufficient sealing pressure
   c. *Man*
      - Operators are not careful
      - Kurangnya pengawasan yang ketat
   d. *Method* (metode).
      - SOP sealing tidak konsisten
      - Lack of strict supervision
   e. *Environment*
      - Dirty sealing area
      - Dust enters the sea

Tabel 1. Processes causing product defects

CTQ	Process	Potential causes
Leaking	Sealing	Unstable sealing temperature
Leaking	Sealing	Insufficient sealing pressure
Leaking	Sealing	Poor lid quality
Reject machine	Filling	Sensor error
Reject machine	Conveyor	Incorrect conveyor settings

Based on interviews with the quality control department and field observations, it was discovered that the sealing temperature was frequently unstable during monitoring. Machine downtime data indicates an increase in disruptions to the sealing machine in July 2024.

The collected and processed data will be analyzed using the Six Sigma improvement proposal tool, DMAIC (Define, Measure, Analyze, Improve, and Control), and Total Quality Management (TQM)[19], [20], [21].

The various types of repair tools are as follows:

1. Check Sheet

   The purpose of this check sheet is to facilitate data collection and analysis, identify problem areas based on the frequency of occurrence of each type or cause, and inform decisions about whether to implement improvements. This is done by recording the frequency of occurrence of product characteristics related to its quality. This data is used as the basis for conducting quality problem analysis.

   The benefits of using a check sheet are as a tool for:

   a. Facilitates data collection, especially to understand how a problem occurs.
   b. Collects data on the types of problems currently occurring.
   c. Automatically organizes data, making it easier to collect.
   d. Separates opinions from facts.

Tabel 2. Inspection Sheet

Observation Date	Sample	Type of Damage	Number of Damaged Products	Percentage of Damage

2. Cause and Effect Diagram

   This diagram is also called a fishbone diagram and is useful for displaying the main factors that influence quality and have an impact on the problem we are studying. Apart from that, we can also see more detailed factors that influence and have consequences for the main factors, as shown in the fishbone-shaped arrow. These main causal factors can be related to:

   a. Material.
   b. Machine.
   c. Man.
   d. Method.
   e. Environment.

3. control chart

   control chart is a graphical representation of data over time that shows the upper and lower limits of a process we want to control so that new data can be quickly compared with previous data. Samples of the process output are taken, and the average of these samples is plotted on a diagram containing words. A control chart is a tool used to monitor and communicate whether an activity or process is in statistical quality control, thus enabling troubleshooting and quality improvement. A control chart is calculated using the following formula:

   a. Calculate the percentage of damage

   $$p = \frac{np}{p}$$

   Information:
   np : Number of failures in the subgroup
   n : Number of inspections in the subgroup in the month.

   b. Calculation of the center line or central line (CL) for all defects in 220 ml cup AMDK products can be calculated using the formula:

   $$\mathrm{CL} = \vec{\mathrm{P}} = \frac{\sum_{\mathrm{i}=1}^{\mathrm{m}} \vec{\mathrm{P}}\mathrm{i}}{\mathrm{m}}$$

Information:
CL = *Central Line*
$\vec{P}$ = Centerline of the proportion control chart.
$\vec{P}i$ = Proportion of the number of products per sample or subgroup
n = Number of observations made

c. Calculation of the center line or upper control limit (UCL) for all the defect in the 220 ml cup AMDK product can be calculated using the formula:

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

Information:
UCL = *Upper Control Limit*
$\vec{P}$ = Centerline of the Proportion Control Chart.
n = Number of samples taken per observation

d. Calculation of the lower control limit (LCL) for all the defect in the 220 ml cup AMDK product can be calculated using the formula:

$$LCL: \vec{P} - 3\sqrt{\frac{\vec{P}\,(1-\vec{P})}{n}}$$

information:
LCL = *Lower Control Limit*
$\vec{P}$ = Centerline of the proportion control chart.
n = Number of samples taken per observation

Results and Discussion

The results of this study indicate that AMDK product defects in January 2024–2025 can be categorized into seven types: incomplete water, leaks, damaged cups, poor quality water, machine rejects, damaged cartons, and damaged lids, all caused by the production process. To address these issues, Six Sigma and Total Quality Management (TQM) tools were used to analyze quality control and propose improvements. Data were collected using a check sheet using the Six Sigma (Define, Measure, Analyze, Improve, Control) approach to strengthen evaluation and provide recommendations for continuous improvement to achieve targets.

The Define stage is the first step in the Six Sigma analysis process. This stage describes the production process and identifies the causes of the problems studied, namely defects affecting a product or Critical to Quality (CTQ). Furthermore, this stage also establishes the direction of improvement to enhance product quality. This stage identifies the production process for 220 ml AMDK cups at CV. Tirta Sasmita, as well as the factors causing problems that lead to product defects, and developing a plan of action to improve product quality so that it meets company standards and consumer needs. The following data was obtained from the company:

Tabel 3. Bottled Water Production Data

No	Month	Production Quantity	Type of Defect							Number of Defects
			W. Full	Leaking	D. Cup	W. Good	M. Rejects	D. Carton	D. Lid	
1	January 2024	4787	122	282	44	50	111	-	7	616
2	February 2024	4388	111	200	75	139	32	-	20	577
3	March 2024	3989	76	231	72	80	70	-	-	529
4	April 2024	597	14	15	30	85	-	-	-	144
5	May 2024	3193	21	160	18	55	40	-	44	338
6	June 2024	3585	114	121	38	217	207	4	27	728
7	July 2024	3184	13	396	25	111	177	6	51	779

8	August 2024	3585	17	213	48	107	274	5	22	686
9	September 2024	1593	13	44	17	47	68	3	53	245
10	October 2024	3586	2	213	60	88	169	2	116	650
11	November 2024	1994	18	152	28	58	111	-	16	383
12	December 2024	2388	127	144	4	65	90	1	50	481
13	January 2025	1593	25	157	14	67	147	2	14	426
Total		38462	673	2328	473	1169	1496	23	420	6582

Source: CV. Tirta Sasmita, 2024-2025

W. Full : The Water is not full
Leaking : Leaking
D. Cup : Damaged Cup
W. Good : The Water is not good
M. Rejects : Machine Rejects
D. Carton : Damaged Carton
D. Lid : Damaged Lid

From these data, it can be seen that the amount of AMDK production in January 2024 – January 2025 was 38,462 per cup with the number of defects being 6,582 per cup during that time period.

Tabel 4. Production Data Defect Types

Defect Type	Number
The Water is not Full	673
Leaking	2.328
Damaged Cup	473
The Water is not good	1.169
Machine Rejects	1.496
Damaged Carton	23
Damaged Lid	420

Source: CV. Tirta Sasmita Periode 2024 - 2025

From the data, it can be seen the types of defects that occur in the production process with 7 types of defects, namely: 673 incomplete water per cup, 2,328 leaks per cup, 473 damaged cups per cup, 1,169 bad water per cup, 1,496 machine rejects per cup, 23 damaged cartons per cup, and 420 damaged lids per cup.

At the measure stage, an analysis will be carried out using a proportion control chart (p-chart), and the Defect Per Million Opportunities (DPMO) value and sigma level will be calculated.

Tabel 5. Overall calculation results of defect type

No	Month	Production Quantity	Number of Defects	Defect Percentage	CL	UCL	LCL
2	January 2024	4787	616	0.13	0.1711	0.1875	0.1548
2	February 2024	4388	577	0.13	0.1711	0.1882	0.1541
3	March 2024	3989	529	0.13	0.1711	0.1890	0.1532
4	April 2024	597	144	0.24	0.1711	0.2174	0.1249
5	May 2024	3193	338	0.11	0.1711	0.1911	0.1511
6	June 2024	3585	728	0.20	0.1711	0.1900	0.1523
7	July 2024	3184	779	0.20	0.1711	0.1900	0.1511
8	August 2024	3585	686	0.19	0.1711	0.1900	0.1523
9	September 2024	1593	245	0.15	0.1711	0.1994	0.1428

10	October 2024	3586	650	0.18	0.1711	0.1900	0.1523
11	November 2024	1994	383	0.19	0.1711	0.1964	0.1458
12	December 2024	2388	481	0.20	0.1711	0.1943	0.1480
13	January 2025	1593	426	0.27	0.1711	0.1994	0.1428
	Total	38462	6582	0.17	0.1711	0.1769	0.1654

Source: Data processed for all types of disabilities for the period 2024 – 2025

Based on the calculation results in table 4 above, a p control chart can then be created which can be seen in the following image:

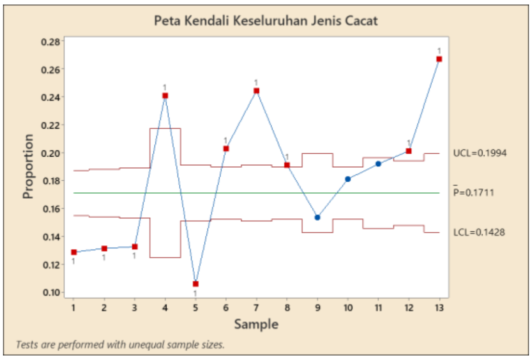

Figure 1. Graph of defective products for the period 2024 – 2025

Figure 1 above shows a p-control chart of the total production volume of defective products from January 2024 to January 2025, based on data obtained from CV. Tirta Sasmita, where the defective products included 7 (seven) classified types.

The graph shows a control chart showing the proportion of defects with an upper control limit (UCL) of 0.2022, a lower control limit (LCL) of 0.1400, and a center line (CL) of 0.1711. Of the 13 samples, most points remained within the control limits, but several exceeded them, indicating that the production process was not yet fully under statistical control. These points within the control limits indicate the presence of special causes influencing process variation, such as machine failures, operator factors, or raw material conditions. Therefore, data outside the control limits were not discarded but were further tested to identify the cause of the process being out of control. After corrective action is taken to address the specific cause, a follow-up control chart can monitor the process's stability after the correction.

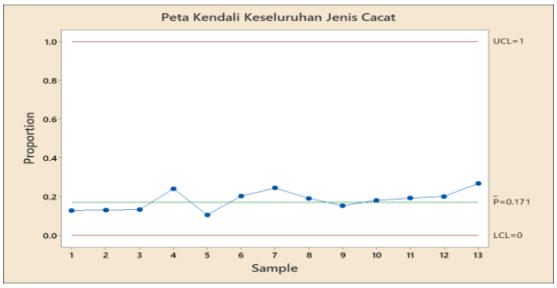

Figure 2. Graph of Revision of Defective Products for the period 2024 – 2025

Based on the revised P control chart results, all defect types are within statistical control limits. This indicates that all defect types have stabilized.

1. Defects Per Million Opportunities (DPMO), Defects per Opportunity (DPO), Yield (Production Success Rate), and Sigma Level
   a. DPMO = (Number of defective products)/(Production quantity × CTQ) x 1,000,000.
   b. DPO = (Number of defective products)/(Production quantity × CTQ).
   c. Yield = (1−DPO)×100%.
   d. Sigma = normsinv ((1,000,000-DPMO)/1,000,000)+1.5
   e. DPU = (Number of defective products)/(Number of)

In this study, seven types of critical quality (CTQ) defects were identified in the AMDK production process: incomplete water, leaks, damaged cups, poor quality water, machine rejects, damaged cartons, and damaged lids. Therefore, each product unit has seven defect opportunities, which are used in the DPMO.

Tabel 6. Results of calculations of DPMO, DPU, DPO, Yield and sigma levels of AMDK defect types

Type of defect	Number of Defects	Production result	CTQ	yield (%)	DPU	DPO	DPMO	Level Sigma
Water Incomplete	673	38462	7	99.75	0.017	0.002	2500	4.31
Leaking	2328	38462	7	99.14	0.061	0.009	8647	3.88
Damaged Cup	473	38462	7	99.82	0.012	0.002	1757	4.42
Bad Water	1169	38462	7	99.57	0.030	0.004	4342	4.12
Machine Rejects	1496	38462	7	99.44	0.039	0.006	5557	4.04
Damaged Carton	23	38462	7	99.99	0.001	0.0001	85	5.26
Damaged Lid	420	38462	7	99.84	0.011	0.002	1560	4.46

Source: Data processed for the period 2024-2025

Based on Table 6, the most common defects in bottled water production from January 2024 to January 2025 at CV. Tirta Sasmita were leaks, with 2,328 cups, and machine rejects, with 1,496 cups. These two defects contributed the most to product quality degradation, with return values of 99.14% and 99.44%, respectively. Other defects, such as incomplete water, substandard water, damaged cups, and damaged lids, were relatively smaller in number. Damaged cartons were the most minor defect, with 23 cups, indicating relatively good packaging quality control.

Based on the DPMO calculation for each defect type, the sigma level ranged from 3.88 to 5.26, indicating that the production process was generally performing at a fairly good level, but still needed continuous improvement, particularly for the dominant defects, namely leaks and machine rejects.

The next stage in the six-sigma method is the analysis stage, which aims to identify the root causes of the dominant defects. The analysis was carried out using statistical tools in the form of a cause-and-effect diagram (fishbone diagram) to identify the root causes of defects in the production process.

The calculation results obtained can be seen in the table below:

Tabel 7. Results of the percentage of defect types

Type of defect	Number of Defects	Percentage (%)	Cumulative Percentage (%)
Water Incomplete	673	10.22	10.22
Leaking	2328	35.37	45.59
Damaged Cup	473	7.19	52.78
Bad Water	1169	17.76	70.54
Machine Rejects	1496	22.73	93.27
Damaged Carton	23	0.35	93.62
Damaged Lid	420	6.38	100
Total	6582	100	100

Source: Processed data on the percentage of types of defects for the period 2024 - 2025

After analyzing the table, the next step is to use a Pareto diagram. The Pareto diagram shows the discrepancies and potential problems, from the largest to the smallest, in order.

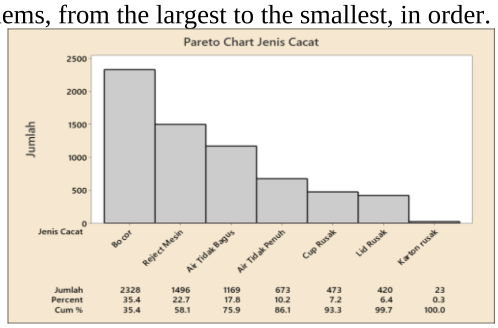

Figure 3. Pareto diagram for the period 2024 – 2025

The diagram above shows that the types of defects in 220 ml bottled water are incomplete water, leaks, damaged cups, bad water, and machine rejects. Based on the image above, it can be seen that the percentage of incomplete water is 10.2%, leaks 35.4%, damaged cups 7.2%, bad air 17.8%, machine rejects 22.7%, damaged lids 6.4% and damaged cartons 0.3%. Based on the Pareto diagram, improvements can be proposed by focusing on the most dominant causes of product defects. The problems of concern are factors that cause significant product damage. The results of this Pareto diagram will be used to determine the cause of the problem. After being identified from the diagram, the data are then rationalized using a cause-and-effect diagram.

Based on the factors described, the cause-and-effect diagram (Fishbone) resulting from the research is as follows:

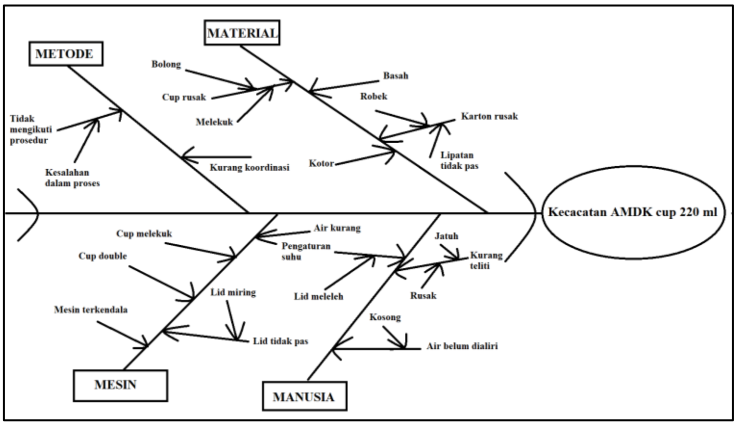

Figure 4. Cause-and-effect diagram (Fishbone)

Tabel 8. Improve

No	Type of Defect	Root Cause	Corrective Actions	PIC
1	Leaking	Inconsistent cup sealing, unstable heating temperature	Standardization of heating temperature and sealing pressure, operator training	Production Manager
2	Water Incomplete	Unstable filter volume setting	Filling machine calibration and volume setting SOPs	Technician
3	Damaged Cup	Inconsistent cup quality from supplier	Supplier selection and raw material inspection	Quality Control
4	Damaged lid	Imprecise lid position	Re-adjustment of cap placement	Technician
5	Reject machine	Frequent machine downtime	Scheduled preventive maintenance	Maintenance

Tabel 9. Control

No	Process	Control Plan	Monitoring Methods	Frequency	Person in charge
1	Sealing	SOP for temperature and pressure sealing	Check Sheet + P-Chart	Daily and weekly	Quality Control
2	Filling	SOP for volume filling	Check Sheet Volume	Daily	Operator
3	Raw Materials	Standard quality cups and lids	Incoming Inspection	Every batch	Quality Control
4	Machinery	Schedule preventative maintenance	Maintenance Log	Weekly	Maintenance
5	Performance Quality	Evaluate defect rates	Pareto and P-Chart	Monthly	Production Manager

Based on the Pareto diagram analysis, the Improve stage focuses on leaks and incomplete air as the main contributors to product defects. Proposed corrective actions and their target achievements are shown in Table 8. Furthermore, the control stage is carried out through routine supervision and periodic evaluation to maintain stable production quality as shown in Table 9.

The next stage, the improvement stage, is the Six Sigma stage, where recommendations for improvement are provided to address the causes of product defects being studied.

1. Problems caused by human factors include product defects due to negligence and inaccuracy in production activities. The solution to this problem is to conduct training and motivate workers to be more careful and

responsible. Furthermore, clear and accurate guidelines are needed for the production process to assist workers, as well as regular, strict supervision.
2. Problems caused by material factors include product defects occurring during raw material processing, during processing, and even after the product has been finalized. To prevent this, recommendations for improvement are expected to promote greater thoroughness in production processes, from raw material processing to finished goods, to prevent defects and to ensure more selective raw material selection.
3. Problems caused by machine factors, resulting in product defects, are machine constraints that disrupt the production process, resulting in substandard products. Proposed improvements include conducting regular inspections, both while the machine is running and when it is stopped.
4. Method factors causing product defects include a lack of coordination in the production process. The proposed improvements provided are to provide direction and hold meetings to update work methods and maximize the implementation of operating standards..

The control phase is the final step in the Six Sigma method. During this phase, the production process is monitored to prevent product defects from recurring and ensure product performance is maintained as expected.

The steps that can be taken at this stage are as follows:
1. Supervise training activities for each worker and ensure that guidelines regarding production processes are implemented properly and correctly.
2. Supervise and maintain the raw materials used and be more selective to ensure that they will not cause product defects.
3. Supervise periodic inspections and maintenance of the machinery used.
4. Supervise work methods.

Total quality management (TQM) is defined as a concept of continuous improvement that involves all employees at every level of the organization to achieve superior quality.
1. Based on production data at CV. From January 2024 to January 2025, Tirta Sasmita found 6,582 defective cups, divided into 7 types, with leaking as the most dominant defect, accounting for 2,382 cups (45.59%). This indicates that the production process is not yet fully stable, and the defect rate still exceeds the company's tolerance limits. Management fully supports the implementation of TQM by providing resources and a clear strategy to enable Six Sigma in effectively reduce defects, especially leaks.
2. Research shows that the production defect rate at CV. Tirta Sasmita still exceeds the tolerance limit, with leaking as the most dominant defect. This has the potential to reduce customer satisfaction because product quality does not meet standards. Therefore, the TQM principle, which emphasizes that quality is measured by customer satisfaction, must be implemented through quality evaluation and follow-up on consumer complaints.
3. Research shows that the production defect rate at CV. Tirta Sasmita still exceeds the tolerance limit, with leaking as the most dominant defect, thus reducing customer satisfaction. To address this, implementing TQM by involving all employees in quality improvement is crucial, so that each production department shares responsibility for preventing the recurrence of defects, particularly leak defects.
4. Based on research, the level of production defects at CV. Tirta Sasmita still exceeds the tolerance limit, with leak defects predominating. In TQM, managing activities as interrelated processes is carried out by strengthening coordination between production departments so that each stage supports each other in defect prevention.
5. Continuous improvement in TQM is implemented through regular evaluation of the production process and control of the causes of defects, especially the dominant leak defects.

The use of statistical data and quality tools in TQM, such as control charts, Pareto charts, and fishbone charts, is necessary to identify root causes of defects and ensure that improvements produce tangible results.

Conclusion

Based on research using Six Sigma and Total Quality Management (TQM) methods on CV. Tirta Sasmita's production from January 2024 to January 2025: 6,582 cups were found defective, with leaks as the dominant defect at 2,328 cups, followed by machine rejects. This indicates that quality issues remain focused on the process and machine performance.

Recommended improvements include operator training and competency development, selection of raw materials in accordance with established quality standards, regular machine maintenance, and consistent implementation of standard operating procedures (SOPs) across all stages of the production process. The application of Total Quality Management (TQM) principles, involving all company elements, supported by a Six Sigma approach as a continuous improvement effort, is expected to reduce product defect rates, increase production process stability, and maintain customer satisfaction, enabling the company to gradually move towards its zero-reject target.

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