



Quality Control

**Quality Control Analysis of Product Defects Using Seven Tools Method & PDCA**Kenny <sup>a\*</sup>, Handi Wilujeng Nugroho<sup>b</sup><sup>a,b</sup>Department of Industrial Engineering, Faculty of Engineering, Universitas Universal, Batam, Indonesia

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## A B S T R A C T

*The injection molding industry faces persistent challenges in maintaining consistent product quality, particularly in high-volume plastic component manufacturing. At the company studied, the Tank Cold Water (CWT) OPP model product exhibited a notably high defect rate, posing risks to production efficiency and customer satisfaction. This problem necessitates a systematic quality control approach to identify root causes and formulate effective corrective actions. This study aims to analyze and control the quality of Tank Cold Water OPP model products using the Seven Tools method and the PDCA cycle. Production defect data from June 2023 to April 2024 (15 observation periods) were analyzed using checksheets, histograms, P-control charts, scatter diagrams, Pareto diagrams, and fishbone diagrams. Results show that out of 2,143,806 total production units, 79,995 defective units were recorded, yielding an average defect rate of 3.73%. Based on the Pareto diagram, Foreign Material is the most dominant defect type at 55.51%, followed by Blackdot (30.34%) and Oily (14.15%). Fishbone diagram analysis identified four main root-cause categories: machine, environment, method, and personnel. Corrective action proposals were formulated using the 5W+1H framework, covering periodic machine maintenance, production area housekeeping, SOP updates, and structured operator training. This research is expected to serve as a reference to pursuit of zero defect production.*

**1. INTRODUCTION**

Quality is one of the key competitive factors in the modern manufacturing industry. In the injection molding sector, product defects are a critical issue that directly impacts production efficiency, cost, and customer satisfaction. High defect rates not only increase rework and waste costs but also threaten a company's reputation and market position. Therefore, systematic quality control is essential to identify, analyze, and eliminate the root causes of defects in the production process [1].

The company examined in this study is engaged in injection molding (plastic part manufacturing), printing, tooling, and secondary processing. Initial observation and interviews with production staff revealed that the Tank Cold Water (CWT) OPP model product — manufactured for the coffee maker parts segment — exhibited a consistently high defect rate over an extended period. The three main defect types

observed were Foreign Material, Blackdot, and Oily, each stemming from different causes related to machine conditions, the production environment, operational methods, and personnel behavior [2].

Given this context, this study applies the Seven Tools method and the PDCA (Plan-Do-Check-Action) cycle as a structured framework for quality improvement. The Seven Tools — comprising checksheets, histograms, P-control charts, scatter diagrams, Pareto diagrams, fishbone diagrams, and flowcharts — are widely recognized instruments for data-driven problem solving in quality management. Combined with the PDCA cycle, these tools enable a systematic approach to identifying dominant defect types, tracing their root causes, and formulating targeted corrective actions. The primary research question addressed in this study is: what are the dominant defect types and their root causes in the Tank Cold Water OPP model production process, and what corrective measures can effectively reduce the defect rate toward zero defect production.

## 2. LITERATURE REVIEW

### 2.1. Quality Control

Quality control is a set of activities carried out to ensure that products or services meet established quality standards. In manufacturing, quality control is critical to minimizing product defects and enhancing customer satisfaction. Systematic quality management reduces rework costs and improves overall production efficiency [3].

### 2.2. Seven Tools

*Seven Tools* refers to seven widely-used quality control instruments that support data-driven problem solving. The seven tools are: (1) Flowchart, (2) Checksheet, (3) Histogram, (4) Control Chart, (5) Scatter Diagram, (6) Pareto Diagram, and (7) Fishbone (Cause-and-Effect) Diagram. These tools are used to systematically identify, analyze, and address the root causes of quality problems [4].

### 2.3. PDCA Cycle

The PDCA cycle (*Plan-Do-Check-Action*) is a continuous improvement framework developed by W. Edwards Deming. The *Plan* phase focuses on problem identification and improvement planning; the *Do* phase on measurement implementation; the *Check* phase on evaluation and root-cause analysis; and the *Action* phase on implementing corrective measures and standardizing improvements [5].

### 2.4. Pareto Diagram

The Pareto Diagram is used to identify and prioritize the most significant problems based on the 80-20 principle, which states that approximately 80% of defects are caused by 20% of defect types. In quality control, this tool determines which defect categories require priority attention [6].

### 2.5. Fishbone Diagram

The Fishbone Diagram (Cause-and-Effect Diagram) is used to identify and analyze factors contributing to a quality problem. These factors are typically categorized into four main groups: Machine, Man, Method, and Environment — commonly referred to as the 4M1E framework [7].

## 3. METHODOLOGY

### 3.1. Research Object

The study was conducted at a company engaged in injection molding (plastic part manufacturing), printing, tooling, and secondary processing. The company was established on June 1, 2009 and is a subsidiary of a Malaysia-based manufacturing group. The research object selected was the Tank Cold Water (CWT) OPP model product, manufactured for the coffee maker parts segment. This product was chosen based on its relatively high defect rate identified through initial observation and interviews with production staff.

### 3.2. Data Collection

This study uses secondary data obtained from the monthly production reports covering 15 observation periods from June 2023 to April 2024. The data includes total production per period and the number of defects classified by type: *Oily*, *Blackdot*, and *Foreign Material*. Data collection also involved direct observation and structured interviews with quality control and production personnel.

### 3.3. Research Framework (PDCA)

The research follows the PDCA cycle as outlined below:

1. *Plan Phase*: Quality problem identification using checksheets, histograms, and scatter diagrams to visualize the distribution and pattern of defects.
2. *Do Phase*: Defect measurement using the P-Control Chart to determine whether the production process is statistically in control.
3. *Check Phase*: Root-cause analysis using the Pareto Diagram to prioritize dominant defects and the Fishbone Diagram to identify contributing factors.
4. *Action Phase*: Formulation of improvement proposals using the 5W+1H framework targeting each identified root cause.

The overall research framework following the PDCA cycle is illustrated in the flowchart below (Figure 1). Each phase is carried out sequentially, and if the defect rate has not been sufficiently reduced after the Action phase, the cycle is repeated from the Plan phase until the zero defect target is achieved.

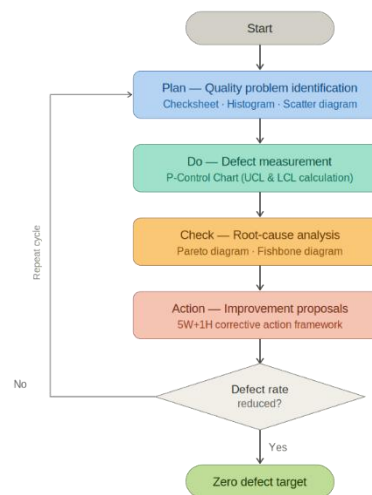


Figure 1. Research Framework Flowchart (PDCA Cycle)

## 4. RESULT AND DISCUSSION

### 4.1. Plan Phase – Quality Problem Identification

Production data for the Tank Cold Water OPP model part over 15 observation periods are summarized in Table 1. The data captures total production volume and the number of defects per type for each period.

Table 1. Production Defect Data – Tank Cold Water OPP Model

No.	Total Production	Oily	Blackdot	Foreign Material	Total Defects	Defect Rate (%)
1	282,546	2,330	6,454	6,620	15,404	5.45%
2	288,601	1,589	3,247	5,011	9,847	3.41%
3	280,170	1,245	1,658	7,185	10,088	3.60%
4	239,983	575	1,350	6,223	8,148	3.40%
5	117,883	230	1,165	1,344	2,739	2.32%
6	140,131	663	1,468	1,572	3,703	2.64%
7	95,387	232	1,336	1,458	3,026	3.17%
8	185,313	514	3,007	5,634	9,155	4.94%
9	95,393	412	1,560	3,523	5,495	5.76%
10	217,562	1,553	1,417	3,555	6,525	3.00%
11	16,119	175	40	134	349	2.17%
12	31,827	295	457	264	1,016	3.19%
13	21,688	227	135	335	697	3.21%
14	109,588	1,074	583	1,376	3,033	2.77%
15	21,615	204	394	172	770	3.56%
<b>Total</b>	<b>2,143,806</b>	<b>11,318</b>	<b>24,271</b>	<b>44,406</b>	<b>79,995</b>	<b>3.73%</b>

(Source: Production Data, 2023–2024)

Table 1 shows that across 15 observation periods, a total of 79,995 defective units were recorded from 2,143,806 total production units — an average defect rate of 3.73%. The histogram visualization of this data reveals that Foreign Material and Blackdot defects consistently constitute the majority of defects across periods, while Oily defects are relatively lower in volume.

**4.2. Do Phase – Measurement with P-Control Chart**

The P-Control Chart was employed to monitor and visualize defect proportions over time. The Upper Control Limit (UCL) and Lower Control Limit (LCL) were calculated based on the aggregate defect proportion across all 15 periods. Table 2 presents the calculated values.

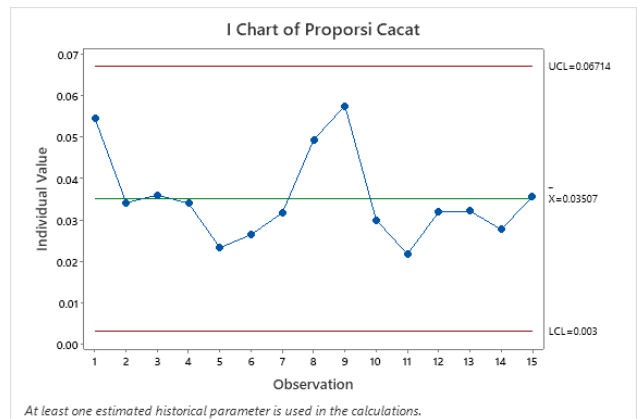
**Table 2.** P-Control Chart Calculations

No.	Total Production	Total Defects	Defect Proportion	UCL	LCL
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1	282,546	15,404	0.054519	0.067	0.003
2	288,601	9,847	0.034120	0.067	0.003
3	280,170	10,088	0.036007	0.067	0.003
4	239,983	8,148	0.033952	0.067	0.003
5	117,883	2,739	0.023235	0.067	0.003
6	140,131	3,703	0.026425	0.067	0.003
7	95,387	3,026	0.031723	0.067	0.003
8	185,313	9,155	0.049403	0.067	0.003
9	95,393	5,495	0.057604	0.067	0.003
10	217,562	6,525	0.029991	0.067	0.003
11	16,119	349	0.021651	0.067	0.003
12	31,827	1,016	0.031923	0.067	0.003
13	21,688	697	0.032138	0.067	0.003
14	109,588	3,033	0.027676	0.067	0.003
15	21,615	770	0.035623	0.067	0.003

(Source: Minitab Data Processing, 2024)

Based on the calculation results presented in Table 2, a control chart was subsequently constructed, as shown in Figure 2.



**Figure 2.** P-Control Chart for the Production of OPP Model Cold Water Tank Parts

(Source: Data processed using Minitab, 2024.)

The P-Control Chart results confirm that all 15 defect proportion data points fall within the statistical control limits (UCL = 0.06714; LCL = 0.003). This indicates that the production process is statistically stable, with no out-of-control observations, and that the analysis can proceed to the next phase without concerns over process instability.

**4.3. Check Phase – Defect Analysis**

**4.3.1 Pareto Diagram**

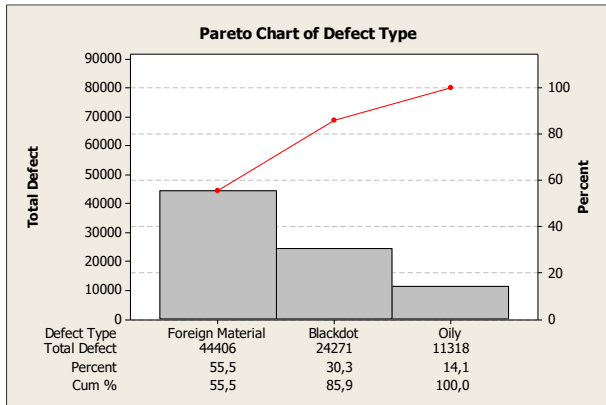
The Pareto Diagram was constructed to identify the most dominant defect type. Cumulative percentage calculations for each defect category are shown in Table 3.

**Table 3.** Cumulative Defect Percentage

Defect Type	Total	Percentage (%)	Cumulative (%)
Foreign Material	44,406	55.51%	55.51%
Blackdot	24,271	30.34%	85.85%
Oily	11,318	14.15%	100.00%
<b>Total</b>	<b>79,995</b>	<b>100.00%</b>	—

(Source: Data Processing, 2024)

The calculation results presented in Table 3 were subsequently converted into a Pareto chart to identify the most dominant type of defect. The resulting Pareto chart is shown in Figure 3.



**Figure 3.** Pareto Chart of Defects in OPP Model Cold Water Tank Parts

(Source: Data processed using Minitab, 2024.)

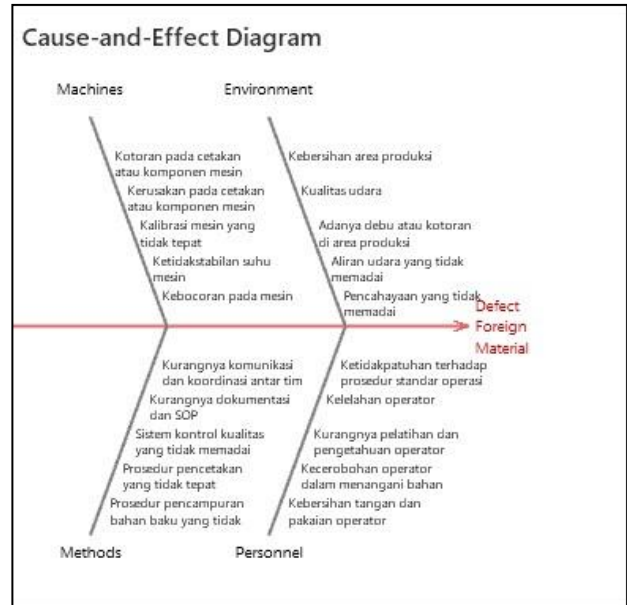
Foreign Material is confirmed as the dominant defect type, accounting for 55.51% of all defects. Together with Blackdot (30.34%), these two types cumulatively represent 85.85% of all defects — consistent with the Pareto principle. This finding directs subsequent analysis and corrective action toward Foreign Material as the primary priority, while Blackdot is identified as a secondary focus.

**4.3.2 Fishbone Diagram Analysis**

A fishbone (cause-and-effect) diagram was constructed to identify the root causes of Foreign Material defects. The analysis yielded four main categories of contributing factors.

- a. *Machine Factor:* Contamination of molds and machine components; damaged machine parts; improper machine calibration; temperature instability; and machine leakage.
- b. *Environment Factor:* Poor production area cleanliness; inadequate air quality; dust accumulation around machines; insufficient airflow; and inadequate lighting conditions.
- c. *Method Factor:* Lack of inter-team communication and coordination; insufficient documentation and SOPs; incorrect molding procedures; and improper raw material mixing procedures.
- d. *Personnel Factor:* Non-compliance with standard operating procedures; inadequate operator training and

knowledge; carelessness in material handling; and poor personal hygiene practices.



**Figure 4.** Fishbone Diagram of Defects in OPP Model Cold Water Tank Parts

(Source: Data processed using Minitab, 2024.)

**4.4. Action Phase – Improvement Proposals (5W+1H)**

Based on the fishbone diagram analysis, improvement actions were formulated using the 5W+1H framework (What, Why, Where, When, Who, How) for each contributing factor. Table 4 summarizes the recommended corrective actions.

**Table 4.** Quality Improvement Implementation Plan (5W+1H)

Factor	Main Problem	Corrective Action (5W+1H)
<b>Machine</b>	Mold contamination; improper calibration; temperature instability; machine leakage	Perform routine cleaning of molds and machine components; replace damaged parts; conduct periodic machine calibration; maintain temperature stability within defined parameters; inspect and repair machine leakages. Responsible party: maintenance team and tooling technicians. Frequency: scheduled preventive maintenance and

<b>Environment</b>	Poor housekeeping; inadequate ventilation; dust in production area; insufficient lighting	as-needed during defect events. Implement routine cleaning schedules for the production floor; maintain air quality through adequate ventilation systems; eliminate dust and contamination sources; improve lighting levels to meet occupational safety standards. Responsible party: cleaning team and maintenance staff. Frequency: daily and per scheduled maintenance.	proper hand and clothing hygiene before entering production. Responsible party: training and production supervision teams. Frequency: periodic training and ongoing supervision.
<b>Method</b>	Lack of coordination; incomplete SOP documentation; incorrect molding and mixing procedures	Improve cross-team communication and coordination; regularly review and update SOPs and work instructions; ensure consistent adherence to correct molding and material mixing procedures. Responsible party: engineering, quality control, and material handler teams. Frequency: before production commencement and upon any process change.	<b>5. CONCLUSION</b>
<b>Personnel</b>	SOP non-compliance; inadequate training; careless material handling; poor personal hygiene	Enforce SOP compliance among all operators; provide structured and periodic training on production processes and material handling; promote careful machine operation practices; ensure operators maintain	<p>These improvement actions must be implemented consistently and in a coordinated manner across all parties involved in the production process. The combined application of machine maintenance, environmental control, method standardization, and personnel development is expected to significantly reduce the occurrence of Foreign Material defects and contribute to achieving zero defect production targets.</p> <p>This study successfully analyzed the quality control of the Tank Cold Water OPP model product using the Seven Tools method and the Plan–Do–Check–Act (PDCA) cycle. Based on the analysis of 15 observation periods from June 2023 to April 2024, involving a total production volume of 2,143,806 units and 79,995 defective units, the results indicate that Foreign Material was the most dominant defect type, accounting for 55.51% of all defects, followed by Blackdot (30.34%) and Oily (14.15%), as identified through Pareto diagram analysis. Furthermore, the P-Control Chart demonstrated that all defect proportion data points remained within the statistical control limits (UCL = 0.06714; LCL = 0.003), indicating that the production process was statistically stable and under control. Fishbone diagram analysis further revealed that the root causes of the dominant Foreign Material defects were associated with four main factors, namely machine, environment, method, and personnel. Based on these findings, improvement strategies were formulated using the 5W+1H framework, including periodic machine maintenance, improved housekeeping in the production area, updates to standard operating procedures (SOPs), and structured operator training. The implementation of these corrective actions is expected to reduce defect rates, enhance process quality, and support the achievement of the company's zero-defect objective.</p>

(Source: Data Processing, 2024)

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