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FMEA-BASED QUALITY IMPROVEMENT IN WASHBASIN MANUFACTURING PROCESS

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Keywords

Defect Analysis; Failure Mode and Effect Analysis; Manufacturing Process; Quality Improvement; Washbasin Production

ABSTRACT

This study analyzed quality control problems in the washbasin manufacturing process at a sanitary product manufacturing company. The study aimed to identify dominant defect types, determine potential failure causes, and propose improvement recommendations to reduce product defects. A quality improvement approach was applied using Pareto analysis, Failure Mode and Effect Analysis (FMEA), fishbone analysis, and the 5W+1H method. Production data from September to November 2025 were analyzed to identify defect distribution and prioritize improvement areas. The results showed that the production process generated 168 defective products from 2,181 produced units, resulting in a defect rate of 7.7%, which exceeded the company target of 6%. The dominant defects identified were cracks, body dust contamination, and body deformation. The FMEA analysis determined the highest-risk failure modes based on the Risk Priority Number values, which were associated with material handling, process control, and operator-related factors. Improvement recommendations were developed through process standardization, operator training, material control improvement, and enhanced inspection procedures. The proposed actions provided a structured approach to improve product quality and reduce potential failures in the washbasin manufacturing process

Kata kunci

FMEA;Pengendalian Kualitas; Produk Cacat; Produksi Wastafel; Proses Manufaktur

ABSTRAK

Permasalahan kualitas pada proses manufaktur dapat menyebabkan penurunan produktivitas dan peningkatan kerugian produksi akibat adanya produk cacat. Penelitian ini telah menganalisis permasalahan pengendalian kualitas pada proses produksi wastafel di salah satu perusahaan manufaktur produk sanitasi. Penelitian ini bertujuan untuk mengidentifikasi jenis cacat dominan, menentukan penyebab potensial kegagalan, serta memberikan usulan perbaikan untuk mengurangi produk cacat. Pendekatan peningkatan kualitas dilakukan menggunakan metode analisis Pareto, Failure Mode and Effect Analysis (FMEA), fishbone diagram, dan metode 5W+1H. Data produksi periode September hingga November 2025 telah dianalisis

untuk mengetahui distribusi cacat dan menentukan prioritas perbaikan. Hasil penelitian menunjukkan bahwa proses produksi menghasilkan 168 produk cacat dari total 2.181 unit produksi dengan tingkat cacat sebesar 7.7%, lebih tinggi dibandingkan target perusahaan sebesar 6%. Jenis cacat dominan yang ditemukan adalah retak, debu body, dan body berubah. Hasil analisis FMEA telah menunjukkan bahwa mode kegagalan dengan nilai Risk Priority Number (RPN) tertinggi berkaitan dengan faktor material, pengendalian proses, dan faktor operator. Usulan perbaikan telah dirumuskan melalui standardisasi proses, peningkatan pelatihan operator, pengendalian material, dan peningkatan prosedur inspeksi. Penelitian ini memberikan pendekatan sistematis untuk meningkatkan kualitas produk dan mengurangi potensi kegagalan pada proses produksi wastafel

INTRODUCTION

Manufacturing industries continuously face increasing competition due to changes in customer expectations, market demands, and product quality requirements. Quality has become one of the critical factors determining a company's competitiveness because customers tend to evaluate products based on reliability, conformity, and performance. In manufacturing systems, maintaining consistent product quality is challenging because variations in materials, machines, production methods, and human factors may lead to process failures and product defects. Defective products not only reduce production efficiency but also increase operational costs through material waste, rework activities, and additional inspection processes. Therefore, companies require an effective quality control approach to identify potential failures and prevent defect occurrence during production processes (Montgomery, 2020).

The sanitary manufacturing industry is one of the sectors that requires strict quality control because product defects can directly affect customer satisfaction and company reputation. PT XYZ, a sanitary product manufacturer, experienced quality problems in its washbasin production process. Based on production records from September to November 2025, the company produced 2,181 units with 168 defective products, resulting in a defect rate of 7.7%. This value exceeded the company's defect target of 6% within the three-month production period. The dominant defects identified in the production process were cracks, body dust contamination, and body deformation. These conditions indicated that the existing production control system still required improvement to reduce potential failures and achieve more stable product quality.

Several studies have applied quality improvement methods to identify and reduce manufacturing defects. Failure Mode and Effect Analysis (FMEA) has been widely used as a systematic approach to identify potential failure modes, evaluate their risks, and determine mprovement priorities. Previous research by Nurdiansyah & Dahda (2026) applied FMEA in bottled drinking water production and identified human factors as one of the dominant causes of defects based on Risk Priority Number (RPN) evaluation. Similarly, Godina et al. (2021) combined DMAIC and Fuzzy FMEA to analyze dominant defects in carton box production and proposed process improvements related to human, material, and machine factors. Other studies have also demonstrated that FMEA can support decision-making in quality improvement by prioritizing failure modes based on severity, occurrence, and detection criteria (Basuki & Chusnayaini, 2021; Montororing et al., 2022). However, most previous studies focused on general manufacturing products, while specific studies addressing defect prevention in sanitary product manufacturing, particularly washbasin production, remain limited.

Although FMEA has been extensively applied in quality improvement research, several limitations remain. Previous studies commonly focused only on identifying failure risks and calculating RPN values, while further analysis of defect causes, and structured improvement planning requires additional problem-solving tools. Integrating FMEA with Pareto analysis, fishbone diagrams, and the 5W+1H approach provides a more comprehensive framework by combining risk prioritization, root cause identification, and corrective action development. This integrated approach allows companies to determine critical failure modes and develop practical improvement strategies based on actual production conditions.

Therefore, this study aimed to analyze quality problems in the washbasin manufacturing process at PT XYZ by applying FMEA, Pareto analysis, fishbone diagrams, and the 5W+1H method. The research contributed to identifying dominant defect types, determining priority failure modes based on RPN values, and developing improvement recommendations to minimize product defects. The findings were expected to provide practical guidance for manufacturing companies in improving process reliability and implementing more effective quality control systems.

METHOD

This study employed a descriptive quantitative research design to analyze quality problems and identify potential failure causes in the washbasin manufacturing process. The research was conducted at PT XYZ, a sanitary product manufacturing company located in Tangerang, Indonesia. The research focused on identifying defective products, determining the dominant defect types, evaluating potential failure risks, and developing improvement recommendations to minimize production defects.

The research procedure was conducted through several sequential stages, including problem identification, data collection, defect analysis, failure risk assessment, root cause identification, and improvement recommendation development. The research framework is presented as follows:

Problem Identification → Data Collection → Defect Classification → Pareto Analysis → FMEA Evaluation → Fishbone Analysis → 5W+1H Improvement Recommendation

The initial stage involved identifying quality problems in the washbasin production process through direct observation and preliminary analysis of production conditions. Data collection was performed using three approaches: observation, interviews, and documentation. Observation was conducted by directly examining the production activities to identify potential sources of defects. Interviews were conducted with relevant production personnel to obtain information regarding production processes, defect causes, and existing quality control practices. Documentation data were obtained from company records containing production quantities and defect information.

The collected data consisted of primary and secondary data. Primary data were obtained from direct observations and interviews related to defect occurrence and production activities. Secondary data consisted of production records from September to November 2025, including total production quantity and defective product data. During the observation period, defect samples were recorded based on defect categories to determine the frequency distribution of each defect type.

The data analysis process was conducted using several quality improvement tools. First, Pareto analysis was applied to identify dominant defect categories based on defect frequency. The Pareto principle was used to determine priority problems that contributed significantly to total defects. Second, Failure Mode and Effect Analysis (FMEA) was applied to evaluate potential failure modes in the production process. Each failure mode was assessed using three parameters: Severity (S), Occurrence (O), and Detection (D). The risk level was determined using the Risk Priority Number (RPN) calculation as shown in Equation (1):

$$RPN=S\times O\times D$$

where:
S represents the severity level of the failure effect,
O represents the probability of failure occurrence,
D represents the ability to detect the failure before reaching the customer.

The failure modes with the highest RPN values were prioritized for further investigation. FMEA was selected because it provides a systematic approach to identify potential failures, evaluate risks, and determine preventive actions in manufacturing processes (Wu et al., 2021).

After determining the priority failure modes, fishbone analysis was performed to identify root causes contributing to product defects. The analysis considered several factors, including human, machine, material, method, measurement, and environmental conditions. Finally, the 5W+1H method was applied to formulate improvement recommendations by defining what actions should be implemented, why improvements were required, who was responsible, where improvements should be applied, when actions should be conducted, and how improvements should be executed.

The final stage of the research involved interpreting the analysis results and developing quality improvement recommendations. The proposed improvements were designed based on the identified failure causes and prioritized risks obtained from the FMEA analysis. This approach provided a structured framework for reducing defect potential and improving quality performance in the washbasin manufacturing process.

RESULTS AND DISCUSSION

Production Defect Analysis

The quality performance of the washbasin manufacturing process was evaluated based on production and defect data collected from September to November 2025. The analysis was conducted

to determine the current defect level and identify the gap between actual production performance and the company quality target.

The production data showed that PT XYZ produced 2,181 washbasin units during the observation period, with 168 defective products identified. The defect percentage was calculated using Equation (1). The evaluation of production performance was conducted to determine the current quality condition and measure the gap between actual defect occurrence and the quality target established by the company. This analysis was important because a high defect rate indicates the presence of process variations that may affect production efficiency, increase material waste, and reduce overall manufacturing performance. Therefore, defect rate calculation was used as the initial step to evaluate the effectiveness of the existing quality control system.

$$\text{Defect \%} = \frac{\text{Number of Defective Products}}{\text{Total Production}} \text{ x } 100\%$$

Based on the calculation, the defect rate reached 7.7%, which exceeded the company target of 6%. This condition indicated that the existing quality control process required improvement to minimize production failures and maintain product consistency. Similar findings were reported by Godina et al. (2021), who highlighted that excessive defect rates in manufacturing systems were often associated with unstable processes and insufficient quality monitoring. Therefore, systematic defect identification is required to establish effective improvement priorities and prevent recurring failures

Table 1. Production Performance and Defect Rate

Description	Quantity
Total production	2,181 units
Total defective products	168 units
Defect percentage	7.7%
Company defect target	6%

Source: Research Data (2025)

Table 1 shows that the defect level in the washbasin production process was still above the acceptable company target. A high defect rate can increase production costs due to material losses, rework activities, and additional inspection requirements. Therefore, further analysis was required to identify the dominant defect types and determine improvement priorities.

Defect Classification Using Pareto Analysis

The defect classification was performed to identify the dominant defect types contributing to total product failures. Pareto analysis was applied because it helps prioritize improvement efforts by identifying defect categories with the highest contribution.

The defect distribution obtained from production records is presented in Table 2.

Table 2. Defect Distribution in Washbasin Production

No	Defect Type	Frequency (Unit)	Percentage (%)	Cumulative (%)
1	Crack	74	44.05	44.05
2	Body dust contamination	58	34.52	78.57
3	Body deformation	36	21.43	100.00
	Total	**168**	**100**	

Source: Research Data (2025)

Table 2 indicates that crack defects represented the largest contribution with 74 defective units or 44.05% of total defects. Body dust contamination was the second largest defect with 58 units (34.52%), followed by body deformation with 36 units (21.43%).

Based on the Pareto principle, the first two defect categories contributed approximately 78.57% of total defects. Therefore, crack defects and body dust contamination became the main priorities for further investigation using Failure Mode and Effect Analysis (FMEA).

The results indicate that defect reduction efforts should focus on controlling critical process factors rather than addressing all defect types simultaneously. Prioritizing dominant defects enables companies to allocate improvement resources more effectively. This result is consistent with the study conducted by Pyzdek (2021), which demonstrated that Pareto analysis could effectively identify critical defect categories and support decision-making in manufacturing improvement programs. By focusing on dominant failure sources, companies can achieve more efficient allocation of improvement

resources.

Failure Mode and Effect Analysis (FMEA)

FMEA was conducted to identify potential failure modes and determine improvement priorities based on risk evaluation. Each failure mode was assessed using three parameters: Severity (S), Occurrence (O), and Detection (D). The Risk Priority Number (RPN) was calculated by multiplying the three assessment values.

$$RPN = S \times O \times D$$

The FMEA evaluation results are presented in Table 3.

Table 3. FMEA Analysis Results

Failure Mode	Potential Cause	Effect	S	O	D	RPN
Crack	Process variation	8	7	6	336	1
Body dust	Cleaning failure	6	7	5	210	2
Body deformation	Process inconsistency	7	5	5	175	3

Source: Research Data (2025)

Table 3 shows that each failure mode has different risk characteristics depending on the severity of its impact, frequency of occurrence, and ability to be detected before reaching customers. The failure modes with higher RPN values should receive priority because they represent greater quality risks. According to Salah et al. (2023), FMEA-based prioritization provides a structured mechanism for evaluating manufacturing risks because it integrates failure impact, occurrence probability, and detection capability. This approach enables organizations to move from reactive inspection toward preventive quality management.

The FMEA approach provides a structured method for transforming defect problems into measurable risks. Instead of only identifying defect frequencies, FMEA enables the company to understand the potential causes and determine appropriate preventive actions.

Root Cause Analysis Using Fishbone Diagram

After identifying the priority failure modes through FMEA, fishbone analysis was performed to investigate the root causes of defects. The analysis considered six main factors: Man, Machine, Material, Method, Measurement, and Environment.

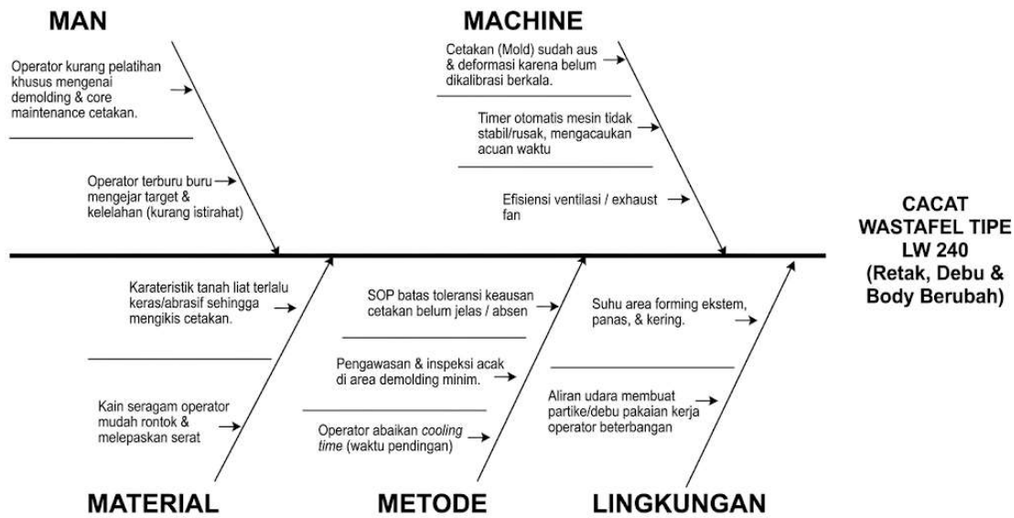


Figure 1. Fishbone Diagram of Washbasin Defect Causes

Source: Research Data (2025)

The fishbone analysis identified that defect occurrence was influenced by several interconnected factors. Human factors included operator handling errors and inconsistent process execution. Machine-related factors involved process condition variation and equipment performance. Material factors were associated with material quality consistency, while method factors were related to production procedures and standardization.

The results indicate that defect problems were not caused by a single factor but resulted from

interactions between production resources. Therefore, improvement actions should address multiple factors simultaneously rather than focusing only on one cause. A similar approach was applied by Angelopoulos et al. (2019), who emphasized that defect problems in manufacturing environments are commonly caused by interactions among human, machine, material, and process factors. Therefore, root cause analysis is necessary to ensure that improvement actions address the actual source of variation.

Improvement Recommendations Using 5W+1H

Based on the FMEA and root cause analysis results, improvement recommendations were developed using the 5W+1H approach. This method was used to define corrective actions systematically by identifying what improvements should be performed, why they were required, who was responsible, where improvements should be implemented, when actions should be conducted, and how implementation should be performed.

Table 4. Quality Improvement Recommendations Using 5W+1H

Problem	Improvement Action	Method
Crack defect	Improve handling procedures and process control	Standard operating procedure improvement and operator training
Body dust contamination	Improve cleaning process and environmental control	Routine cleaning and inspection improvement
Body deformation	Improve parameter consistency and process monitoring	Production parameter standardization

Table 4 presents improvement recommendations developed based on the identified failure causes. The proposed actions focused on improving process consistency, reducing human error, and strengthening quality control activities. This improvement approach is supported by Arredondo-Soto et al. (2021), who stated that structured corrective action planning combined with root cause analysis can improve the sustainability of quality improvement initiatives in manufacturing organizations.

The integration of Pareto analysis, FMEA, fishbone analysis, and 5W+1H provided a comprehensive approach for quality improvement. Pareto analysis identified priority defects, FMEA evaluated failure risks, fishbone analysis identified root causes, and 5W+1H translated findings into practical improvement actions.

CONCLUSION

This study analyzed quality problems in the washbasin manufacturing process using an integrated quality improvement approach consisting of Pareto analysis, Failure Mode and Effect Analysis (FMEA), fishbone analysis, and the 5W+1H method. The results showed that the production process generated 168 defective products from 2,181 produced units, resulting in a defect rate of 7.7%, which exceeded the company target of 6%. The Pareto analysis identified crack defects as the most dominant defect type with a contribution of 44.05%, followed by body dust contamination with 34.52% and body deformation with 21.43%.

The FMEA analysis determined the priority of failure modes based on Risk Priority Number (RPN) values. Crack defects obtained the highest RPN value of 336, indicating that this failure mode became the primary improvement priority. The second and third priorities were body dust contamination with an RPN of 210 and body deformation with an RPN of 175. These findings indicated that quality problems were mainly associated with process variation, cleaning control, and production consistency.

Based on the root cause analysis, improvement recommendations were developed using the 5W+1H approach. The proposed improvements included process standardization, operator training, improved cleaning procedures, material control, and production parameter monitoring. The integration of FMEA with root cause analysis provided a systematic approach to identify critical failure modes and formulate appropriate improvement actions for the washbasin manufacturing process.

This study was limited to the analysis and formulation of improvement recommendations without evaluating the effectiveness of implementation after improvement actions were applied. Future research can evaluate the impact of the proposed improvements through implementation trials and compare defect performance before and after improvement to measure the actual quality improvement achievement.

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