QUALITY CONTROL ANALYSIS OF PEW ENAMEL WIRE USING PARETO AND FISHBONE

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Abstract

PT Cakra Wire is a manufacturing company that produces enamel wire for various industrial applications, such as electric motors, transformers, and other electromagnetic devices. During the production process, the company faces quality issues and defective products, which potentially increase production costs and reduce process efficiency. Production data from January to February 2026 indicate that PEW type enamel wire exhibits a relatively high defect rate compared to other product types. This situation necessitates an analysis of the types of defects occurring and the factors contributing to their formation during the production process. The aim of this study is to identify the types of defects in PEW enamel wire, determine the dominant defect type, and analyze the underlying causes. A descriptive research design employing a mixed-methods approach was selected. Data collection involved observations, interviews, document analysis, and the evaluation of operational records regarding product defects from January to February 2026. The analysis was conducted using specific instruments from the "Seven Quality Tools" check sheets, Pareto charts, and cause-and-effect diagrams. The results reveal three main types of defects in PEW products rough surface texture, severe wire breaks (non-compliant with standards), and surface irregularities. Pareto analysis identifies rough surface texture as the dominant defect type. Cause-and-effect analysis demonstrates that these defects are influenced by factors related to man, machine, method, and material. Consequently, the company must strengthen production process monitoring, perform regular machine maintenance, intensify material inspection, and improve adherence to established work procedures by operating personnel. These findings are expected to provide the company with valuable insights for increasing the effectiveness of quality control and reducing defect rates.

Keywords: Quality control, TQM, Check Sheet, Pareto chart, and Fishbone Diagram.

Introduction

The manufacturing industry plays a vital role in national economic growth. Given technological advancements and increasingly intense global competition, manufacturing companies are required to consistently produce high-quality goods to meet customer demand and ensure their competitiveness. Product quality is a crucial factor, as it affects not only customer satisfaction but also production process efficiency, operating costs, and the company's long-term business sustainability. Therefore, companies must implement effective quality control systems to minimize defects during the production process.

The enamel wire sector is a vital segment of the manufacturing industry for the development of modern industry. Enamel wire is a key component in various electromagnetic systems and devices, such as electric motors, generators, transformers, and other electronic equipment. Driven by rising demand for electric vehicles, renewable energy solutions, and electronic products, the enamel wire market continues to grow steadily. This trend requires companies to produce products that comply with established technical specifications and quality standards.

PT Cakra Wire is an enamel wire manufacturer that produces various types, such as UEWF, UEW, PEW, and EIW Based on production data from July through December 2025, PEW products exhibit relatively high and stable production volumes. However, defect rate data show that the PEW product type has the highest average defect rate 29%, compared to other product types. In August 2025, the defect rate for PEW even reached 42%, indicating a quality issue that requires special attention. This high defect rate suggests ongoing inconsistencies during the production process, which could potentially increase production costs due to rework, scrap, and a decline in the company's productivity.

In addition to defect data, observations and interviews with production personnel indicate that the enamel wire manufacturing process involves several stages that have the potential to cause product defects. Quality issues can stem not only from machinery but also from human factors, materials, and work methods applied during production. Therefore, a more in-depth analysis is needed to identify the most prevalent types of defects and their root causes, so that the company can determine appropriate corrective actions.

Quality control refers to the efforts undertaken by a company to ensure that its products meet established standards. One of the most widely used methods in quality control is the Seven Quality Tools, which are various tools used to systematically collect, process, and analyze quality data (Dale et al., 2016). This study uses three main tools: a check sheet to identify and categorize defect types, a Pareto chart to prioritize problems based on frequency of occurrence, and a fishbone diagram to identify the root causes of product defects (Heizer et al., 2020).

Research conducted by Abidin et al. (2022) shows that the use of pareto charts and fishbone diagrams enables companies to identify the most prevalent types of defects and determine the key factors affecting product quality. These findings indicate that the Seven Quality Tools approach is effective for prioritizing quality improvements, allowing companies to focus their resources on issues that have the greatest impact on product defect rates.

Another study by Marlina et al. (2024) also shows that a combination of check sheets, pareto charts, and fishbone diagrams can be used to analyze quality issues more systematically. This research emphasizes that structured defect data collection via check sheets serves as a crucial foundation for identifying dominant defect types and root causes requiring improvement. The results show that the application of the seven quality Tools helps companies formulate more effective corrective actions to reduce product defect rates.

Based on the background and previous research, this study is important because the high defect rate of PEW products can affect production efficiency, increase rework and scrap costs, and reduce the company's productivity. Although previous research has shown that the Seven Quality Tools are effective for analyzing product defects, this study specifically focuses on PEW product quality issues at PT Cakra Wire. Therefore, this study aims to identify the types of defects in PEW products, determine the dominant defects that need to be prioritized, and analyze the root causes of defects using check sheets, Pareto charts, and fishbone diagrams. The results of this study are expected to provide recommendations for PT Cakra Wire on how to improve quality control and reduce product defect rates.

Methods

Research Design

This study employs a descriptive research design with a mixed methods approach to identify and describe the types of defects that occur in the PEW production process at PT Cakra Wire. The descriptive approach was used to characterize defects in the production process, while the mixed methods approach integrated quantitative data from production defect records with qualitative data obtained through observations and interviews. This combination aimed to provide a more comprehensive understanding of product defects and the factors contributing to their occurrence. This study was conducted at PT Cakra Wire, a manufacturing company specializing in the production of enamel wire located in Bandung, West Java. The focus of this study is the PEW production process, which has the highest defect rate compared to other types of enamel wire produced by the company.

Research Object and Data Sources

The subject of this study is the production process of PEW products at PT Cakra Wire. This study focuses on PEW products because, based on company data from July through December 2025, this product line exhibits the highest average defect rate compared to other types of enamel wire. The purpose of this study is to identify the types of defects that occur during the production process and the factors that cause them.

This study uses primary and secondary data. Primary data was obtained through direct observation and interviews with personnel involved in production and quality control. Secondary data was sourced from company documents, specifically production records and PEW product defect data covering the period from January to February 2026. This data was used to analyze the types, numbers, and patterns of defects observed during the study period.

Data Collection Procedures

Data collection was conducted through observation, interviews, document reviews, and examination of company records. Direct observation was carried out in PEW's production area to understand the stages of the production process and the working conditions associated with each step. The stages observed included raw material inspection, the drawing process, varnish coating, and product inspection and packaging. The observations also aimed to identify potential causes of defects that arise during production, such as machine condition, operator work practices, material usage, and the application of work methods.

Interviews were conducted with personnel involved in production and quality control, including the plant manager and staff from the production, quality assurance, PPIC, and engineering departments. These interviews aim to gather information regarding common types of defects, production process conditions, procedures for handling defective products, and suspected causes of these defects. Additionally, documentation is used to collect production data, defect records, and other supporting documents related to the quality control process. All defect data from the January–February 2026 period was then compiled for further analysis.

Data Analysis

Data analysis was conducted using three of the Seven Quality Tools the check sheet, the pareto chart, and the fishbone diagram. The initial stage involved compiling defect data into a check sheet. The check sheet was used to record, categorize, and summarize the types and numbers of defects found in PEW products during the study period. The results from the check sheet were used to provide an initial overview of defect patterns and the most frequently occurring defect types.

Defect data was then analyzed using a pareto chart to identify the most dominant types of defects. The pareto chart ranks defect types based on their frequency or contribution to the total number of defects,

enabling the company to determine which issues should be prioritized. Once the dominant defects were identified, the analysis continued using a fishbone diagram to identify their root causes based on human, machine, method, and material factors. Information from observations, interviews, and company documents was used to substantiate the identification of causes for each factor. The results of this analysis served as the basis for formulating proposals for quality control improvements in the PEW production process.

Data Validity

Data validity is ensured through source triangulation by comparing information obtained from several data sources, namely company defect data, results of direct field observations, interviews with relevant parties, and available supporting documents. Source triangulation is applied so that the information obtained does not come from a single source, but rather so that one set of data reinforces another. Defect data is used to identify patterns, types, and the prevalence of defects, while the results of observations and interviews are used to confirm actual conditions in the production process and to explore the underlying causes observed in the field. Thus, the use of these various data sources is expected to enhance the accuracy and validity of the analysis results and minimize bias in drawing research conclusions.

Results and Discussion

Analysis of Product Defect Data Using a Check Sheet

The product defect analysis was conducted using a checklist that recorded the number of defects in PEW-type products during January and February 2026. This record categorizes defects into three types: gross defects, surface defects with bumps, and breakage defects with non-standard weights. This checklist is used to identify the types of defects that occur most frequently during the production process, thereby serving as a basis for analyzing the root causes of the issues in subsequent stages

Tabel 1. Check Sheets Produk Cacat Tipe PEW Januari 2026

Date	Production volume (Kg)	Types of Deffect Products			Number of Deffects Products (Kg)
		Rough (Kg)	A lump is present on the surface (Kg)	Weight that does't meet PEW standards (Kg)	
3 January	420		12		12
6 January	1084		11	96	21
7 January	419	96			9
8 January	1859	41	3		7
9 January	211			151	15
10 January	169	96			9
13 January	144	99		96	1
14 January	296	73	44		1
15 January	242	89		187	2
17 January	106	28		165	4
18 January	984			241	2
19 January	157	14	52		1
20 January	531	14	41		1
21 January	285	37			3
22 January	281	92			9
23 January	182	54			5
26 January	171			43	4
28 January	473			88	8
29 January	212			55	5
Total	140	12	407	1122	2

Based on Table 1. the company's total production in January 2026 reached 14,085 kg, with 2,771 kg of defective products. The highest volume of defective products was recorded on January 17 at 445 kg, while the highest production volume occurred on January 15 at 2,428 kg. These data indicate a positive correlation between production volume and the amount of defective products, where an increase in production tends to be followed by an increase in the amount of defective products.

Of the three types of defects found, coarse defects had the highest total at 1,242 kg, with the highest single- day amount occurring on January 17 at 280 kg. Broken defects with non-standard weights ranked second with a total of 1,122 kg, with the highest single-day amount on January 18 at 241 kg. Meanwhile, surface defects involving lumps had the lowest total, at 407 kg or about 3% of total production, with the high

est amount recorded on January 6 at 96 kg. Overall, coarse defects and broken products with non -standard weights were the two most dominant types of defects during the January period, making them the primary focus of the product quality analysis.

Table 2. Check sheets Produk Cacat Tipe PEW Februari 2026

Date	Production volume (Kg)	Types of Deffect Products			Number of Deffects Products (Kg)
		Rough (Kg)	A lump is present on the surface (Kg)	Weight that does't meet PEW standards (Kg)	
3 February	726	61		104	165
4 February	858	44	49	80	173
5 February	1173	77	52	110	239
6 February	410	65		77	142
7 February	312	48		51	99
11 February	1114	180		33	213
12 February	573	134			134
13 February	730	112		46	124
14 February	471			84	84
16 February	236	36			36
19 February	523	77	67		144
21 February	662	74	77		151
22 February	565	75	73		148
Total	8353	983	318	585	1886

Based on Table 1.2 the company's total production in February 2026 reached 8,353 kg, with 1,886 kg of defective products. Of the three types of defects, gross defects were the most common, totaling 983 kg higher than the 585 kg of non-standard breakage defects and the 318 kg of surface defects involving lumps. This indicates that coarse defects remain the primary issue in the PEW-type production process during that period.

Looking at the daily data, the highest number of defective products occurred on February 5, with a total of 239 kg of defects out of a total production of 1,173 kg. On February 11, a significant number of defects was also recorded 213 kg dominated by coarse defects totaling 180 kg. Conversely, the lowest number of defective products occurred on February 16, with a total of only 36 kg of defects out of a total production of 236 kg; on that day, only coarse defects were found, with no other types of defects. Surface defects, such as lumps, do not always appear on every production day but still contribute to the total number of defective products on the days they occur.

Overall, the check sheet data for January and February 2026 show that coarse defects consistently ranked among the defect types with the largest contribution during both periods; therefore, this data can serve as a basis for further root-cause analysis using Pareto charts and fishbone diagrams. Data on the types and percentages of defective products

Tabel 4. Data on the Types and Percentages of Defective Products, January 2026

January		
Production Volume (Kg)	14085	
Number of Deffects	Total (Kg)	Percentage
Rough	1242	9%
Weight that does't meet PEW standards	1122	8%
A lump is present on the surface	407	3%
Total Deffect	2771	20%

Based on Table 4. it was found that the company's total production in January reached 14,085 kg. Of this total, 2,771 kg or about 20% of the total output—consisted of defective products. This percentage indicates that the number of products failing to meet quality standards remains relatively high, as approximately 20% of total production was defective. These data suggest that the quality of production during January still requires attention to reduce the number of defective products in subsequent production periods. The high defect rate can also impact production efficiency, as products that do not meet standards cannot be utilized optimally.

Based on Table 4. above, the percentage of defective products is calculated using the following formula:

$$\text{Percentage of Failed Products} = \frac{\text{Number of Failed Product Types}}{\text{Total Production Volume}}$$

$$\text{Rough} = \frac{1242}{14085} = 9\%$$

$$\text{Weight that does't meet pew standards} = \frac{1122}{14085} = 8\%$$

$$\text{A lump is present on the surface} = \frac{407}{14085} = 3\%$$

$$\text{Total disability} = \frac{1242 + 1122 + 407}{14085} = 20\%$$

The most prevalent type of defect in January was gross defects, totaling 1,242 kg, or 9% of total production. This figure makes gross defects the largest contributor to the company's total defective products. In addition, there were also non-standard severe breakage defects, totaling 1,122 kg, or 8% of total production. These percentages indicate that the two defect types are quite close in volume and both contributed significantly to the high defect rate in January. Combined, these two defect types accounted for the majority of total defective products during the production period.

Meanwhile, surface defects involving bumps accounted for the smallest number of defects compared to other defect types, totaling 407 kg or 3% of total production. Although the quantity is lower, this defect type still falls under the category of products that do not meet the company's quality standards. Overall, the total defects occurring in January across all defect types amounted to 2,771 kg, or 20% of total production. This figure indicates that the defect rate remains relatively high, necessitating the company's attention in efforts to improve quality and reduce defective products in subsequent production processes. This data also confirms that coarse defects and severe breakage defects do not meet the company's standards.

Tabel 5. Data on the Types and Percentages of Defective Products, February 2026

February		
Production Volume (Kg)	8353	
Number of Deffects	Total (Kg)	Percentage
Rough	983	12%
Weight that does't meet PEW standards	585	7%
A lump is present on the surface	318	4%
Total Deffect	1886	23%

Based on Table 5. in February the company's total production reached 8,353 kg. Of that amount, 1,886 kg were found to be defective, representing a total defect rate of 23%. This figure indicates that during the production process, some products still fail to meet the company's quality standards. Such a high defect rate can certainly affect the overall quality of production. Furthermore, this situation can also lead to losses due to products that cannot be fully utilized. Therefore, the defect data needs to be analyzed further so that the company can identify which parts of the production process still need improvement.

Based on Table 5 above, the percentage of defective products is calculated using the following formula:

$$\text{Percentage of Failed Products} = \frac{\text{Number of Failed Product Types}}{\text{Total Production Volume}}$$

$$\text{Rough} = \frac{983}{8353} = 12\%$$

$$\text{Weight that does't meet pew standards} = \frac{585}{8353} = 7\%$$

$$\text{A lump is present on the surface} = \frac{318}{8353} = 4\%$$

$$\text{Total disability} = \frac{983 + 585 + 318}{8353} = 23\%$$

Based on defect type, coarse defects were the most prevalent, totaling 983 kg, or 12%. This figure was higher than that for non-standard severe breakage defects, which totaled 585 kg (7%), and surface defects involving lumps, which totaled 318 kg (4%). These data indicate that the primary issues in the PEW production process are largely caused by coarse defects. Although surface defects involving lumps have the lowest quantity, this type of defect still contributes to the total defective product count. The differences in quantities across each defect type suggest that defect rates vary across production processes, and this can serve as a guide for the company in determining where to focus quality improvement efforts. Overall, the total defects occurring in February across all defect types amounted to 1,886 kg, or 23% of total production. This figure indicates that the defect rate remains relatively high, necessitating the company's attention in efforts to improve quality and reduce defective products in subsequent production processes.

Through this defect percentage data, the company can identify the types of defects that occur most frequently during the production process. This information can be used as a basis for evaluation to improve product quality in the next period. By identifying the dominant types of defects, the company can more easily conduct root cause analysis

Analysis of the Most Common Defects Using a Pareto Chart

This section discusses the results of the analysis using a Pareto chart to reinforce the percentage data presented earlier. The Pareto chart is used to identify the types of defects that should be prioritized and require further analysis, by ranking them from the largest to the smallest contribution to the total number of defective products.

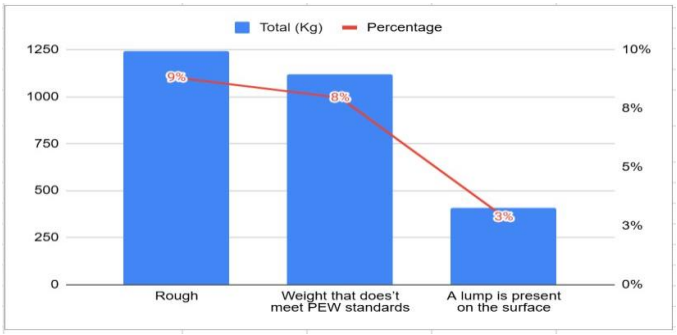

Figure 1. Pareto Chart Enamel January 2026

Based on the Pareto chart in Figure 1. It can be seen that there are three types of defects that occur in the enamel process: coarse defects, broken pieces with non-standard weights, and surface defects involving bumps. In terms of percentage, coarse defects are the most common type, accounting for approximately 9% of total production. This indicates that issues with the product's surface roughness remain a dominant contributor to defects in the production process.

Broken pieces with non-standard weights rank second, accounting for about 8%. Although the difference is not significant compared to coarse defects, this type of defect still occurs frequently and warrants attention because it contributes significantly to the total number of defective products. Meanwhile, surface defects involving bumps are the type of defect with the lowest contribution, at around 3%. Although the least common, this type of defect still warrants attention because it continues to affect the final product quality.

Based on this data, it is clear that all three types of defects contribute to the total number of defects, albeit to varying degrees. Therefore, quality control should not focus solely on a single type of defect but should be comprehensive to ensure that the production process runs more smoothly and produces more consistent products.

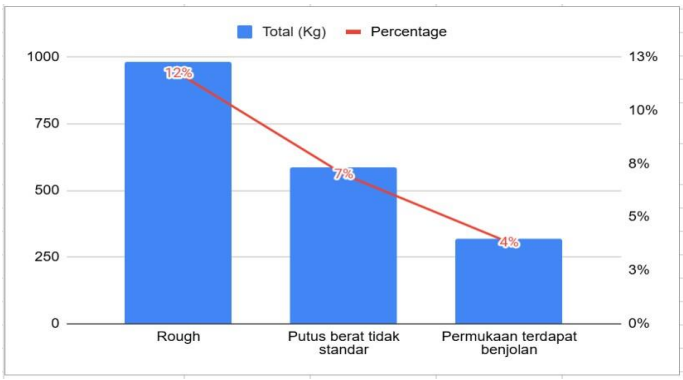

Figure 2. Pareto Chart Enamel February 2026

Based on the Pareto chart in Figure 2. Trough defects once again emerged as the most common type of defect, accounting for approximately 12% of total production higher than their share in January. These data indicate that rough product surfaces remain a major issue in the enamel production process, so the company needs to focus more on monitoring and improving processes related to product surface quality.

In addition to rough surface defects, there are also defects involving broken pieces with non - standard weights, accounting for about 7%. Although the number is not as high as that of rough surface defects, this type of defect is still found quite frequently during the production process. Meanwhile, surface defects involving bumps are the type with the lowest contribution, at about 4%, indicating that these defects occur relatively less frequently than other types of defects during this period.

Based on the Pareto charts in Figures 4.1 and 4.2, it can be concluded that during the period from January to February 2026, coarse defects consistently constituted the most dominant type of defect in the enamel

process, accounting for approximately 9% in January and increasing to about 12% in February. Although other defect types continued to appear in both periods, their contributions were not as significant as those of coarse defects; therefore, the primary issue most significantly affecting the total defects during these two periods was coarse defects.

Analysis of the Primary Causes of Defects Using a Fishbone Diagram

A cause-and-effect diagram (fishbone diagram) is used to help identify the relationship between the problems that occur and the factors causing defective products in the enamel wire production process. Through this diagram, the causes of the problems can be analyzed in a more targeted manner so that the company can identify which areas need improvement to ensure product quality remains in line with established standards. In this study, the fishbone diagram was developed based on the results of a Pareto chart, which showed that there are three dominant types of defects in the PEW production process: coarse defects, breakage with non-standard weight, and surface defects involving bumps.

The fishbone diagram analysis in this study uses the 4M approach, namely man, machine, material, and method. These four factors are interrelated in the enamel wire production process; therefore, if one of these factors does not function properly, the likelihood of defective products increases. The following presents an analysis of the causes for each type of defect.

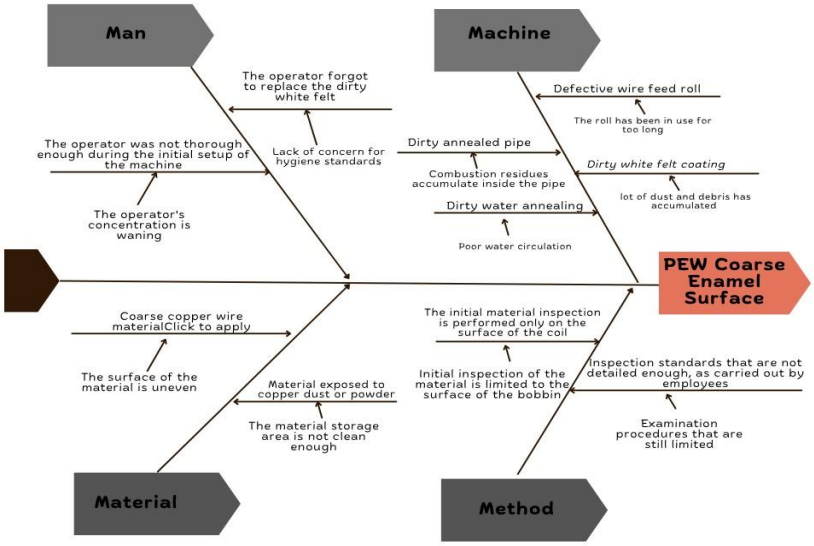

Figure 3. Fishbone Diagram Coarse Enamel Surface

Based on the results of interviews and observations, human error is one of the causes of rough surface defects in enamel wire products. Operators who are not thorough enough during the initial machine setup cause production parameters to deviate from standards, resulting in an unstable wire drawing process and a rough wire surface. Additionally, operators who forget to replace soiled white felt allow dust and material residue to adhere to the enamel wire, resulting in a rough wire surface.

Regarding machine factors, dirty or defective white felt and wire feed rolls can cause dust to adhere to the wire surface and create friction during production, resulting in a rough wire surface. Furthermore, annealing pipes and annealing water that are rarely cleaned can carry dirt particles that adhere to the wire surface and affect the quality of the final product. From a material perspective, the rough surface of the copper wire directly affects the final product, as an uneven surface results in a less smooth enamel coating. Additionally, if the material is exposed to dust or copper powder, small particles may adhere to the wire's surface, increasing the likelihood of rough surface defects.

Regarding the method factor, incomplete product inspections make some defects difficult to detect, allowing products with rough surfaces to still pass through to the next process. Furthermore, insufficiently detailed inspection standards prevent the inspection process from operating at full capacity, as some minor defects on the wire surface often go unnoticed during checks.

Based on these analysis results, rough surface defects are most frequently caused by machine and human factors. On the machinery side, dirty or poorly maintained white felt, wire guide rolls, pipes, and annealing water are the main causes of dirt buildup and friction on the wire surface. Meanwhile, on the human side, a lack of precision on the part of operators during initial machine setup and negligence in replacing dirty white felt also reduce the stability of the production process.

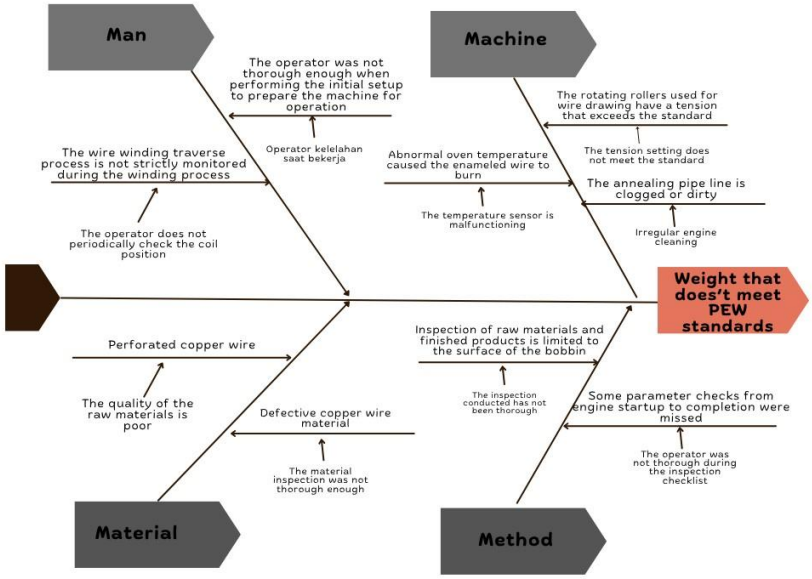

Figure 4. Fishbone Diagram Weight that does't meet standards

Based on the results of the analysis using a Pareto chart, non-standard severe breakage defects were the most common type of defect after rough defects; therefore, further analysis is needed to determine the causes. Regarding human factors, operators who are not meticulous when setting up the machine cause production parameters to deviate from standards, resulting in an unstable wire drawing process and making the wire more prone to breakage. Additionally, inadequate supervision of the traverse process on the bobbin leads to untidy and unstable wire winding positions, causing uneven wire tension and making the wire more prone to breakage.

Regarding machine factors, excessively high capstand tension subjects the wire to excessive tension, thereby reducing its strength and making it more prone to breakage. Furthermore, abnormal oven temperatures can cause the enamel wire to burn and become brittle, while worn or defective wire guide rolls can generate excessive friction, making the wire more prone to breakage.

From a material standpoint, copper wire with holes has a weaker structure and is therefore unable to withstand the machine's pulling force effectively. Additionally, defective material or material with a rough surface can reduce the wire's strength, thereby increasing the risk of wire breakage. Regarding the method, insufficiently detailed inspection of machine parameters prevents substandard machine conditions from being detected immediately, so production continues even when the machine is unstable. Furthermore, incomplete product inspections prevent operators from promptly detecting the potential for wire breakage.

Based on the results of this analysis, non-standard severe wire breaks are primarily influenced by machine and material factors. Regarding machine factors, excessively high tension capstand settings, abnormal oven temperatures, and worn wire feed rolls can make the wire more prone to breaking. Meanwhile, regarding material factors, copper wire with holes or surface defects tends to have lower strength, making it more susceptible to breaking during the drawing process.

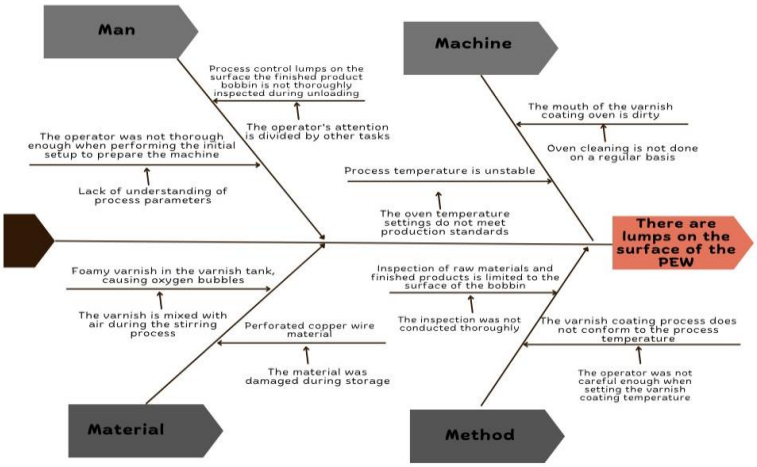

Figure 5. Fishbone Diagram There are lumps on the surface

Based on the results of the analysis using a Pareto chart, surface defects in the form of bumps account for the smallest percentage compared to other types of defects. Nevertheless, this type of defect still requires attention and further analysis. Regarding human factors, operators who are not meticulous enough during the initial machine setup cause the coating process parameters to deviate from standards, resulting in suboptimal varnish coating and an uneven wire surface. Additionally, insufficient process control during bobbin unloading prevents surface defects from being detected immediately, as inspections are sometimes limited to specific sections.

Regarding machine factors, a dirty varnish coating oven inlet can disrupt the enamel coating process, resulting in an uneven coating and causing small bumps. Furthermore, unstable process temperatures prevent the varnish coating process from running perfectly, leading to an uneven enamel layer and the appearance of spots or bumps on the product's surface. In terms of materials, foaming varnish causes air bubbles to form during the coating process, which then adhere to the wire's surface and result in small bumps after drying. Additionally, the porous nature of the copper wire makes it difficult for the varnish coating to adhere perfectly, causing the wir e's surface to become spotty.

Regarding method-related factors, incomplete product inspection causes some minor defects to go unnoticed, allowing products with a spotty surface to still pass to the next stage. Furthermore, a varnish coating process conducted at temperatures deviating from the standard causes the enamel finish to be uneven, resulting in bumps or spots on the wire's surface in the final product.

Based on these analysis results, the causes of surface defects specifically bumps are most closely related to machine and material factors. Regarding machine factors, a dirty oven opening and unstable process temperatures can disrupt the varnish coating process, resulting in an uneven enamel coating. Meanwhile, regarding material factors, foamy varnish and holes in the copper wire can cause air bubbles and prevent the coating process from being completed properly.

Overall, the analysis of the three types of defects shows that machine-related factors are the most consistently occurring cause and the single largest contributor to defective products in the PEW production process. Based on field observations, some of the machines in use are quite old, so their performance is no longer optimal, which affects the stability of the production process and the quality of the resulting products. In addition to machinery-related factors, substandard material conditions and the fact that material inspections are still conducted using sampling methods at the beginning of production are also significant causes, as not all parts of the material can be thoroughly inspected, meaning defects in the middle or end of the wire coils often go undetected.

Based on these findings, the following corrective actions can be proposed: developing more detailed SOPs for machine setup and consistently monitoring their implementation; scheduling routine maintenance and cleaning for the white felt, wire feed rolls, pipes, and annealing water, as well as the inlet of the varnish coating oven; readjusting and monitoring machine parameters such as capstand tension and oven temperature to ensure they remain within standard ranges; improving raw material quality control, including inspecting the condition of the varnish and the surface of the copper wire before use; and strengthening inspection standards and expanding material inspection methods beyond sampling-based approaches, so that defective products can be detected earlier and the number of defects in subsequent production processes can be significantly reduced.

Conclusion

Based on the results of a study conducted on the production process of PEW at PT Cakra Wire during January and February 2026, three main types of defects were identified: rough surface defects, wire breakage due to weight not meeting standards, and uneven surfaces with protrusions. These defects occurred repeatedly during the observation period and indicate that quality issues persist in the PEW production process. Analysis of inspection sheets and Pareto charts shows that rough surface defects were the dominant type of defect in both months. In January 2026, rough surface defects amounted to 1,242 kg, or about 9% of total production, while in February 2026, they amounted to 983 kg, or about 12% of total production. Therefore, rough surface defects are the top priority for quality improvement because they account for the largest proportion of defective products compared to other types of defects.

Based on the fishbone diagram analysis, the occurrence of defects in PEW production was influenced by human, machine, material, and method factors. Human factors were related to insufficient operator accuracy during machine setup and process monitoring. Machine factors included unstable machine conditions, temperature settings, and supporting components that could affect the production process. Material factors were related to the quality of the copper wire and varnish used, while method factors were associated with inspection procedures that had not been carried out comprehensively and consistently. Therefore, quality improvement efforts can be directed toward routine machine maintenance, more thorough material inspection, increased operator supervision, and the consistent implementation of inspection procedures throughout the production process. These improvements are expected to reduce the number of defective products and support the maintenance of PEW product quality in accordance with company standards.

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