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Quality Control of Furniture Products With SQC and FMEA Methods at UD. XYZ

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Abstract – **In the era of globalization, increasingly fierce industrial competition forces companies to improve product quality and production efficiency. This study is focused on UD. XYZ iron fabrication company, which experienced a bench product defect rate of 13.68%, exceeding the intended tolerance standard of 9%. The purpose of this study is to analyze the quality control processes of bench furniture products at UD. XYZ to reduce the defect rate. For this purpose the writer used the Statistical Quality Control (SQC) and Failure Mode and Effect Analysis (FMEA) methods. Based on the data obtained, there are six types of defects that occur during the production process of furniture bench products with the largest percentage of defects being missing color (19.9%), followed by broken bench pads (19.1%), and broken rubber feet (17.7%). Based on the RPN calculation, the first highest RPN is obtained for the type of missing color defect of 210, which is caused by the lack of worker accuracy. Second, the bench pad broke at 210, which is caused by the worker being too hard when hitting the bench pad. Third, the rubber foot broke by 180 which is caused by the worker hitting the rubber foot too hard. To reduce the defect rate it is recommended for the company management to provide more supervision and training to the workers.**

Keywords *– Failure Mode and Effect Analysis, Furniture, Statistic Quality Control, Quality Control.*

INTRODUCTION

In this era of globalization, the industry is growing rapidly, although accompanied by an unstable economy. Competition is getting tougher, requiring every company to compete to survive. One of the keys is to improve the quality control of raw materials and production processes, without neglecting the profit target [1]. Quality is the customer's assessment based on their experience of the product/service. This experience is measured by comparing customer requirements and expectations with the product/service received, [2]. In essence, quality is the value contained in a product that is able to provide satisfaction for consumers, [3]. The higher the quality of the product, the more marketable it is. Quality control in the production process is also beneficial for reducing production costs. Therefore, checking and reviewing the quality of raw materials is essential to improve product quality, satisfy consumers, and reduce production costs, [4]. In an industrial context, quality control is not just about ensuring the products produced meet the set standards. More than that, quality control also serves as a tool to maximize the efficiency and effectiveness of the production process. Thus, companies can reduce production costs, increase productivity, and ultimately, increase profits, [1].

UD. XYZ is a company engaged in iron fabrication. The company operates with a repetitive system, and receives orders from its partner companies. The products produced by UD. XYZ is furniture made of iron including: chairs, benches, tables, physical frames, and bipod frames. Where the products that are very often ordered are stool products, due to the proliferation of coffee shops with unique concepts that increase the demand for stool products that match the concept and aesthetics of the shop. As a company engaged in iron fabrication, UD. XYZ plays an important role in meeting market needs for quality iron furniture. With various products produced, such as chairs, stools, tables, physical frames, and bipod frames, UD. XYZ contributes to

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advancing the local industry and meeting the growing market demand. The production of stool products starts from raw materials in the form of iron sheets and undergoes several production steps to become furniture, starting from cutting, forming, assembling, leveling, coloring, ovens installing accessories, and sorting. At each step of the production process, inspections are carried out by operators with the aim of preventing defects in furniture products.

Based on observations and secondary data from the company, several defects were found in several production processes, such as: uneven surfaces due to the leveling process, missing colors due to the coloring process, embossed paint due to the coloring process, different leg diameters due to the forming process, broken rubber feet due to the process of installing accessories, broken bench pads due to the process of installing accessories. Although UD. XYZ has implemented various steps in the production process to ensure product quality, there are still some challenges faced. Some defects found in the production process indicate that there is still room for improvement in the existing quality control system. Research on bench products has production scheduling data that is carried out 6 days a week. During the period October 2023 to April 2024, the bench product had a production rate of 13,973 units. However, the high bench production rate has a high defect rate of 1,912 units, with a defect percentage of 13.68%. Stool products have a percentage of defects that have exceeded the company's defect tolerance standard of 9%. With these problems, research is carried out to control the quality of furniture bench products using the Statistical Quality Control method and Failure Mode and Effect Analysis, with the hope of improving the quality of furniture bench products at UD. XYZ.

METHOD

Design, Place and Time

The research was conducted at the UD. XYZ. The research was conducted in January 2024 until the data was fulfilled.

Data Types and Sources

The variables related to the problem can be identified and will be analyzed as follows. The dependent variable is the variable that can change due to the influence of the independent variable. In this final project research, the dependent variable is the quality of bench products at UD. XYZ. Independent variables are variables that affect other variables or cause or change another variable. The independent variables in this study are production quantity data used for the period October 2023 to April 2024. Data on the number of defects used is during the period October 2023 to April 2024. The types of defects in bench products include different leg diameters, uneven surfaces, missing colors, embossed paint, broken rubber feet, and broken bench pads.

Research Stages

The problem-solving stage starts with (1) grouping the data on the number of defects displayed in the histogram. (2) Creating a pareto diagram to identify priority problems to be resolved immediately. (3) Creating the steps of the bench making process using process diagrams. (4) Creating a scatter diagram to determine the relationship between the independent variable and the dependent variable. (5) Create a P attribute control map to determine whether or not the defect data is under control, if the data is under control the study will fail, if the data is not under control the study will continue to create a fishbone diagram to determine potential problem areas. (6) Brainstorming the QC division, a method used to find ideas for problem solving. This method is carried out together with the Quality Control division team.

(7) Continued the stage of proposed improvements analysis of the FMEA method. (8) Determine the modes of failure of the production process, identify the effect of the production process, determine the severity value (S), identify the cause of failure, determine the control action (current control), determine the detection value (D), calculate the risk priority number (RPN), and provide recommendations for improvement. then (9) make quality control recommendations for defects in bench products. And lastly (10) enter the results and discussion then continue with conclusions and suggestions.

Statistical Quality Control

Statistical Quality Control method is a problem-solving technique used to monitor, control, analyze, manage and improve products and processes using statistical methods, [5]. So, it can be used as a tool to prevent defects by rejecting and accepting various products resulting from the production process, as well as efficiency efforts, [6]. SQC is also used as a technique for managing and controlling processes in both manufacturing and services using statistical methods, [7]. Quality control tools are check sheets,

histograms, pareto diagrams, process diagrams, scatter diagrams, control charts, and cause and effect diagrams, [6]. In principle, each control map has central line, upper control line, and lower control line. Central line is the center limit of the control map. With the following Eq. (1).

$$\text{CL} = p = \frac{\sum np}{\sum n} \quad (1)$$

p = Average product damage
Σnp = Total number damaged
Σn = Total number inspected

Upper Control Limit (UCL) is the upper limit of the control map, while Lower Control Limit (LCL) is the lower limit of the control map. With the following Eq. (2) and (3).

$$\text{UCL} = p + 3\frac{\sqrt{p(1-p)}}{n} \quad (2)$$

$$\text{LCL} = p - 3\frac{\sqrt{p(1-p)}}{n} \quad (3)$$

p = Average product damage
n = Production quantity

Failure Mode and Effect Analysis

Failure Mode and Effect Analysis is a structured procedure to identify and prevent as many failure modes as possible. Failure Mode and Effect Analysis is used to identify the sources and root causes of a quality problem, [8].

RESULT AND DISCUSSION

Data Collection

The data taken are data on the amount of production, data on the number of defects and data on the types of defects in bench furniture products for the period October 2023 to April 2024.

Table 1. Production Data of Bench Furniture Products

Month	Production Quantity (Unit)
October 2023	1.068
November 2023	3.290
December 2023	775
January 2024	2.893
February 2024	2.281
March 2024	2.489
April 2024	1.177
Total	13.973

Table 2. Bench Furniture Defect Count Data

Month	Number of Defects (Unit)
October 2023	45
November 2023	291
December 2023	219
January 2024	354
February 2024	461
March 2024	252
April 2024	290
Total	1.912

Table 3. Bench Furniture Product Defect Type Data

Month	Number of Defects (Unit)						
	Different Leg Diameters	Uneven Surfaces	Missing Colors	Embossed Paint	Broken Rubber Feet	Broken Bench Pads	Total Defects (Unit)
October 2023	5	10	7	6	8	9	45
November 2023	32	62	46	44	51	56	291
December 2023	26	37	36	37	36	47	219
January 2024	41	69	58	54	65	67	354
February 2024	57	92	74	70	82	86	461
March 2024	32	53	40	36	44	47	252
April 2024	37	57	47	43	52	54	290
Total	290	230	380	308	338	366	1.912

Histogram

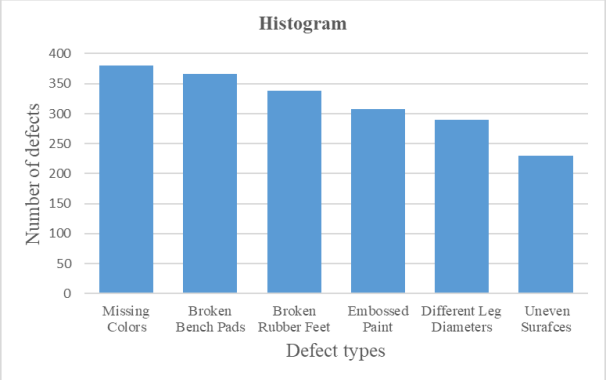

Figure 1. Histogram of Bench Furniture Products

Based on figure 1, it can be seen that the interval order of the types of defects is the highest to the lowest, including: 380 units of missing color, 366 units of broken bench pads, 338 units of broken rubber feet, 308 units of embossed paint, 290 units of different foot diameters, and 230 units of uneven surfaces.

Pareto diagram

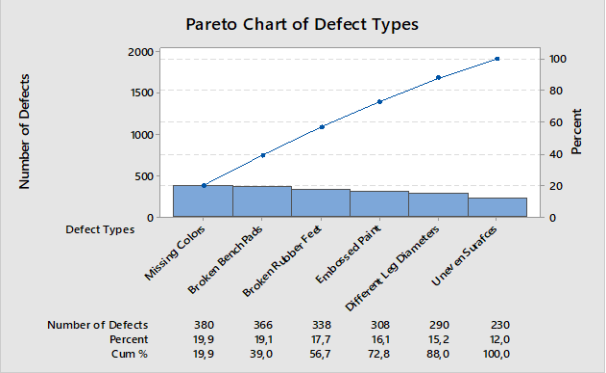

Figure 2. Pareto Diagram

Based on figure 2, it can be seen that the highest type of defect is missing color with a percentage of 19.9%, followed by broken bench pads with a percentage of 19.1%, then broken rubber feet with a percentage of 17.7%, then embossed paint with a percentage of 16.1%, then different foot diameters with a percentage of 15.2%, and uneven surfaces with a percentage of 12.0%. Through this pareto diagram, it can be seen what defects need to be addressed first.

Process diagram

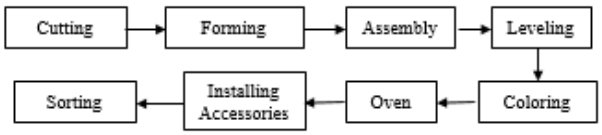

Figure 3. Process Diagram

Based on figure 3, it can be seen that there are 8 steps to produce bench furniture products. The flow of the production process begins with cutting the iron sheet. After that, it is formed into several parts of the bench, namely the seat and legs of the bench. After that, the parts that have been formed are assembled by welding to become a bench. Further, leveling is carried out with the aim that the entire surface of the bench is flat. After that, coloring is done with powder paint with the aim that the coloring can be evenly distributed and make the bench more attractive. Then do the oven so that the powder paint sticks to the bench. Next, the process of installing accessories is carried out, namely rubber feet and bench pads. Finally, the benches that have been installed with accessories will be sorted to recheck the quality of the benches.

Scatter diagram

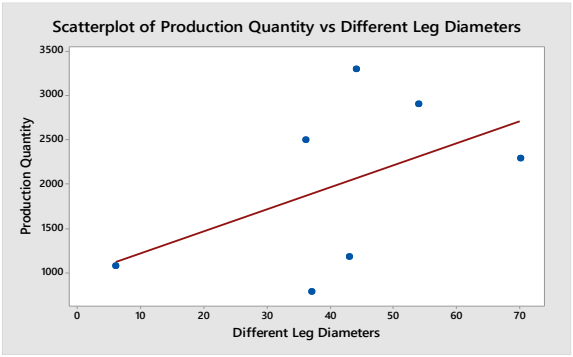

Figure 4. Scatter Diagram of Production with Different Leg Diameters

Based on figure 4, it shows that the regression line has a direction from left to right and the position of the points is near the regression line, which means that there is a strong positive relationship between the production variable and the different foot diameter variable, where the higher the amount of production, the higher the number of different types of foot diameter defects.

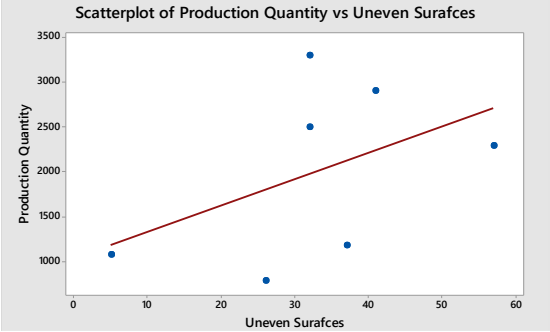

Figure 5. Scatter Diagram Production With Uneven Surface

Based on figure 5, it shows that the regression line has a direction from left to right and the position of the points is near the regression line, which means that there is a strong positive relationship between the production variable and the uneven surface variable.

Figure 6. Scatter Diagram Production with Missing Colors

Based on figure 6, it shows that the regression line has a direction from left to right and the position of the points is near the regression line, which means that there is a strong positive relationship between the production variable and the missing color variable.

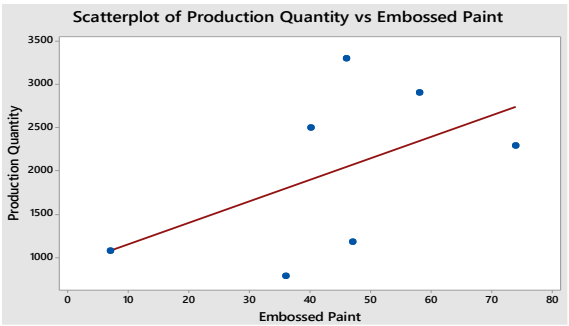

Figure 7. Scatter Diagram Production with Embossed Paint

Based on figure 7, it shows that the regression line has a direction from left to right and the position of the points is near the regression line, which means that there is a strong positive relationship between the production variable and the paint variable.

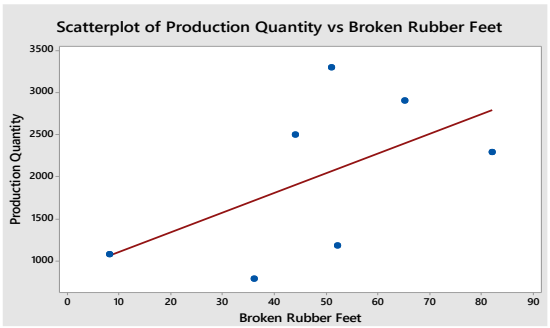

Figure 8. Scatter Diagram Production with Broken Rubber Feet

Based on figure 8, it shows that the regression line has a direction from left to right and the position of the points is near the regression line, which means that there is a strong positive relationship between the production variable and the broken rubber foot variable.

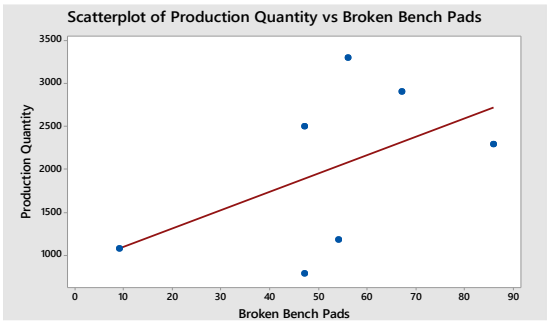

Figure 9. Scatter Diagram Production with Broken Bench Pads

Based on figure 9, it shows that the regression line has a direction from left to right and the position of the points is near the regression line, which means that there is a strong positive relationship between the production variable and the variable bearing bench break.

Control Chart

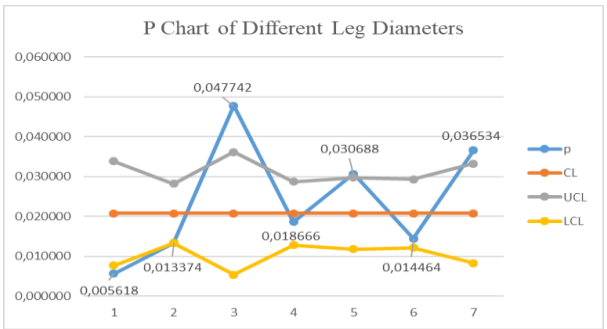

Figure 10. P Control Map of Different Leg Diameters

Based on figure 10, it shows that there are four values of the proportion of defects outside the control limits, namely October 2023, December 2023, February 2024 and April 2024. This indicates the presence of abnormal variations in the process, which may be caused by various factors.

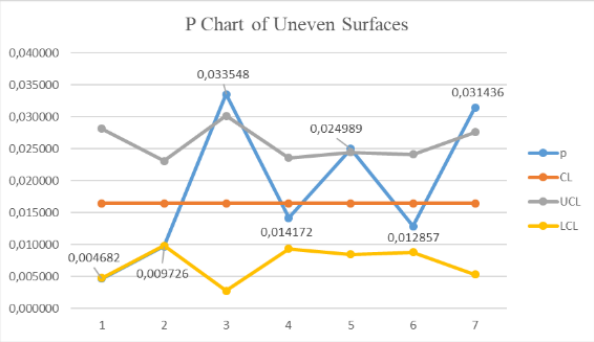

Figure 11. P Control Map of Uneven Surfaces

Based on figure 11, it shows that there are five values of the proportion of defects outside the control limits, namely October 2023, November 2023, December 2023, February 2024 and April 2024. This indicates an abnormal variation in the process, which may be caused by various factors.

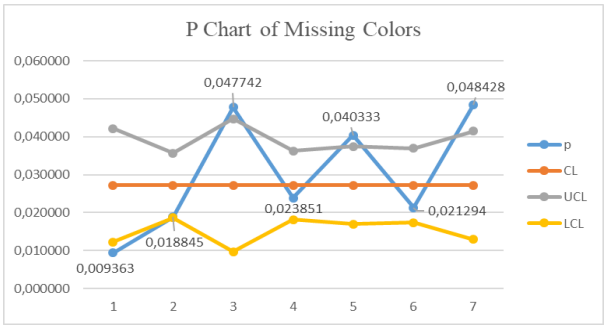

Figure 12. P Control Map of Missing Colors

Based on figure 12, it shows that there are four values of the proportion of defects outside the control limits, namely October 2023, December 2023, February 2024, and April 2024. This indicates the presence of abnormal variations in the process, which may be caused by various factors.

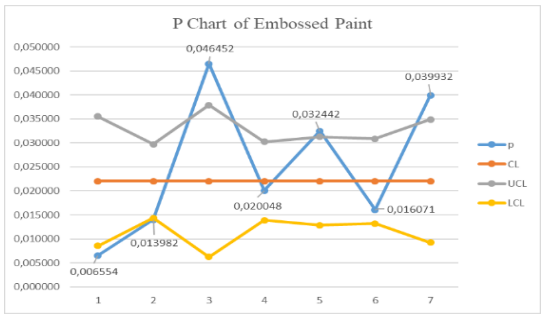

Figure 13. P Control Map of Embossed Paint

Based on figure 13, it shows that there are five values of the proportion of defects outside the control limits, namely October 2023, November 2023, December 2023, February 2024, and April 2024. This indicates an abnormal variation in the process, which may be caused by various factors.

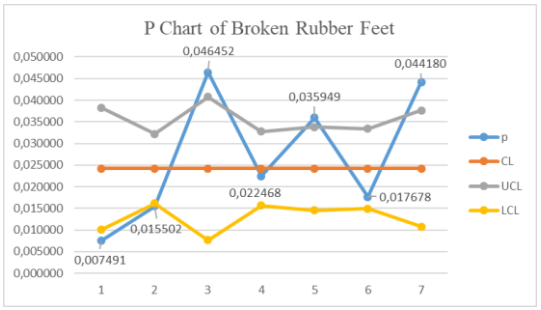

Figure 14. P Control Map of Broken Rubber Feet

Based on figure 14, it shows that there are five values of the proportion of defects outside the control limits, namely October 2023, November 2023, December 2023, February 2024, and April 2024. This indicates an abnormal variation in the process, which may be caused by various factors.

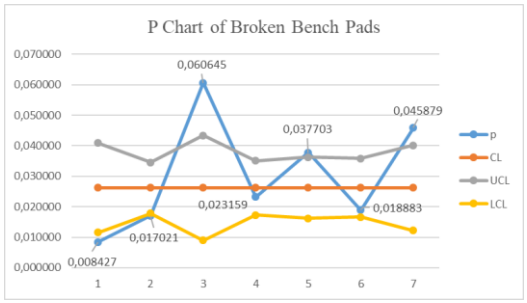

Figure 15. P Control Map of Broken Bench Pads

Based on figure 15, it shows that there are five values of the proportion of defects outside the control limits, namely October 2023, November 2023, December 2023, February 2024, and April 2024. This indicates an abnormal variation in the process, which may be caused by various factors.

Fishbone diagram

Fishbone Diagram also known as Ishikawa diagram is a method used to identify the root of a problem by visualizing the relationship between various factors contributing to a problem. In the manufacturing world, Kaoru Ishikawa identified six contributing factors referred to as the 6Ms: man, machine, method, material, measurement, and mother nature (environment). Dr. Kaoru Ishikawa developed this method, and since then, Fishbone diagrams have become an important tool in various industries, [9].

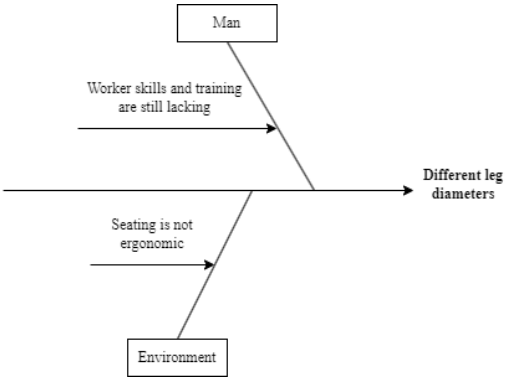

Figure 16. Fishbone Diagram of Different Leg Diameters

Based on figure 16, there are two main factors that cause problems in the production process. First, from the human side, the cause of defects is due to the lack of worker skills and training. As a result, the quality and consistency of the results were inadequate. Secondly, in terms of the environment, the process of shaping the diameter of the leg is carried out on uncomfortable short chairs, so workers get tired and unfocused quickly, which results in variations in the final result.

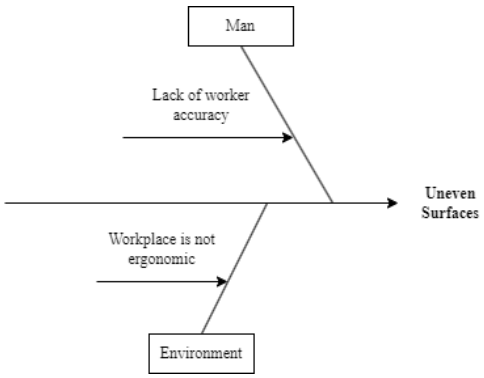

Figure 17. Fishbone Diagram of Uneven Surfaces

Based on figure 17, it shows two main factors that cause production problems. First, in terms of humans, caused because workers are less careful when doing the leveling process so that there are still some uneven surfaces. Second, in terms of the environment, because the workplace is not ergonomic, namely a short seat, hot and dusty temperatures make it uncomfortable so that there are still some uneven surfaces. This analysis was conducted using the human factors analysis method, which involves problem identification, direct observation, workload analysis, ergonomic evaluation, feedback collection, and data analysis with the 7 tools of quality.

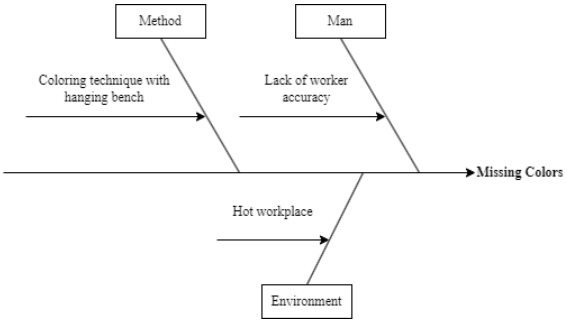

Figure 18. Fishbone Diagram of Missing Colors

Based on figure 18, it shows three main factors that cause production problems. First, in terms of humans, it is because workers are less evenly distributed when coloring so that there are still some surfaces that are not exposed to paint. Second, in terms of the environment, it is because the workplace is too hot, so there are still some product defects. Third, due to the coloring method that hangs the bench too heavy because it has to lift each bench that will be colored, which can affect workers in the coloring process. This analysis was conducted using the human factors analysis method, which involves problem identification, direct observation, workload analysis, ergonomic evaluation, feedback collection, and data analysis with the 7 tools of quality.

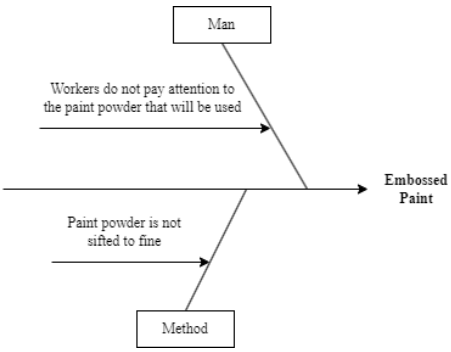

Figure 19. Fishbone Diagram of Embossed Paint

Based on figure 19, it shows two main factors that cause production problems. First, in terms of humans, it is because workers do not pay attention to the paint powder that will be used so that there is still paint powder that is still lumpy. Second, in terms of methods, it is because the paint powder is not sifted until it is smooth so that there is no clumpy paint powder. This analysis was conducted using the human factors analysis method, which involves problem identification, direct observation, workload analysis, ergonomic evaluation, feedback collection, and data analysis with the 7 tools of quality.

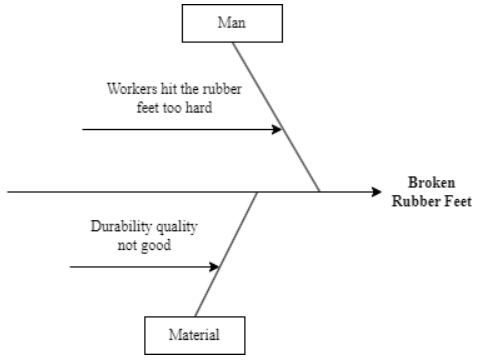

Figure 20. Fishbone Diagram of Broken Rubber Feet

Based on figure 20, it shows two main factors that cause production problems. First, in terms of humans, it is because workers are too hard when hitting the rubber feet so that the rubber feet break. Secondly, in terms of materials, it is because the quality of the rubber foot durability is not good so that the rubber feet break easily. This analysis was conducted using the human factors analysis method, which involves problem identification, direct observation, workload analysis, ergonomic evaluation, feedback collection, and data analysis with the 7 tools of quality.

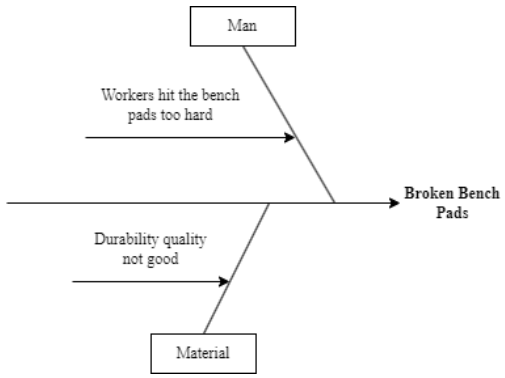

Figure 21. Fishbone Diagram of Broken Bench Pads

Based on figure 21, it shows two main factors that cause production problems. First, in terms of human caused because the worker is too hard when hitting the bench bearing so that the bench bearing breaks. Secondly, in terms of material, it is because the quality of the durability of the bench bearing is not good so that the bench bearing is easily broken. This analysis was conducted using the human factors analysis method, which involves problem identification, direct observation, workload analysis, ergonomic evaluation, feedback collection, and data analysis with the 7 tools of quality.

Failure mode and effect analysis

The failure mode and effect analysis method is the improvement strategy stage when the SQC method tool is the cause and effect diagram which identifies potential problem areas that are prioritized for improvement which will be used as a reference in this method, [10]. This FMEA procedure is carried out by calculating the RPN (Risk Priority Number) value by minimizing the risk of failure by reducing severity, occurrence and increasing detection capability, [11]. To get the RPN value, you can apply the formula Eq. (4).

$$RPN = S \times O \times D \quad (4)$$

S = Severity
O = Occurrence
D = Detection

An example of calculating the RPN (Risk Priority Number) for the failure mode of different leg diameters with the cause of failure of lack of worker skills and training is as follows.

RPN = S x O x D
= 5 x 6 x 4
= 120

Table 4. Risk Priority Number

Modes of Failure	***Effect of Failure***	**S**	***Cause of Failure***	**O**	***Current Control***	**D**	**RPN**
Different Leg Diameters	Caused the bench furniture product to be reshaped due to the mismatch of the diameter of the bench legs with one another, which resulted in excess production costs.	5	Worker skills and training are still lacking	6	Provide training to workers	4	120
			Seating is not ergonomic	6	Replace with ergonomic seating	5	150
Uneven Surfaces	Causing bench furniture products to be re-leveled because there are still uneven surfaces, which requires excessive additional time and labor.	3	Lack of worker accuracy	6	Provide supervision and guidance to workers	7	126
			Workplace is not ergonomic	6	Moving the workplace to a more spacious and shaded area	5	90
Missing Colors	Causing bench furniture products to have to be re-colored because	5	Lack of worker accuracy	6	Provide supervision and guidance to workers	7	210

Modes of Failure	***Effect of Failure***	**S**	***Cause of Failure***	**O**	***Current Control***	**D**	**RPN**
	there are surfaces that have lost color, which results in excessive production costs.		Hot workplace	8	Increase air ventilation	4	160
			Coloring technique with hanging bench	6	Changing the coloring technique without hanging the bench	5	150
Embossed Paint	Causing bench furniture products to have to be re-colored because there are still surfaces with embossed paint, which results in excessive production costs.	4	Workers do not pay attention to the paint powder that will be used	6	Rechecking the paint before coloring	5	120
			Paint powder is not sifted to fine	6	Sifting 3 times	4	96
Broken Rubber Feet	Causing bench furniture product accessories, namely these rubber feet, to break so that they have to be replaced with new rubber feet, which results in excessive production costs.	5	Workers hit the rubber feet too hard	6	Provide training to workers	6	180
			Durability quality not good	8	Replace rubber feet with better durability quality	4	160
Broken Bench Pads	Causing bench furniture product accessories, namely bench pads, to break so that they have to be replaced with new bench pads, which results in excessive production costs.	5	Workers hit the bench pads too hard	7	Provide training to workers	6	210
			Durability quality not good	8	Replace bench pads with better durability quality	3	120

Based on the results of the RPN calculation (Table 4) for FMEA bench furniture products, several risks are obtained that have the highest priority level for quality control proposals to minimize the possibility of failure. The calculation of the highest RPN value is 210 of the type of color defect missing with the cause of the defect, namely the lack of accuracy of workers with proposed improvements to provide supervision and guidance to workers and this is included in the high RPN category, so improvements must be made immediately at this time. Then the high RPN value is 180 from the type of disability of broken rubber feet with the cause of the disability, namely the worker is too hard when hitting the rubber feet with a recommendation for improvement to provide training to workers and this is included in the medium RPN category, so the treatment is still in an effort to make improvements. Then the highest RPN value is 160 from the type of missing colors disability with the cause of the disability, namely a hot workplace with a recommendation for improvement to add air ventilation and this is included in the medium RPN category, so the treatment is still in an effort to make improvements

CONCLUSION

This study has identified six main types of defects in the production process of bench furniture at UD. Benteng Mas, with missing colors (19.9%) and broken bench pads (19.1%) as the most frequent defects. Based on the analysis, recommendations to improve product quality include increased supervision and guidance of workers, more intensive training, additional air ventilation, use of better quality rubber feet, and replacement of the seat with an ergonomic design. The implementation of these recommendations is expected to reduce the defect rate, especially in the process of coloring and installing accessories, thus improving the quality of stool furniture significantly.

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