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Analysis of Quality Control of Fabric Products Using Statistical Quality Control Methods and Failure Mode and Effect Analysis

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Abstract

Companies in the industrial world, both manufacturing and service industries, are required to face market competition in order to compete and survive. One thing that companies need to pay attention to is the quality of the products produced. Good product quality will make consumers like the product. Therefore, improving product quality must be considered by the company. One of the companies that produces fabric, namely PT. XYZ, has a problem of not knowing the level of quality of the fabric produced, so this study aims to determine the quality of the product and provide suggestions for improvement to the company. There are defects in fabric production, namely double weft with a percentage of 27.7%, loose weft 26.7%, broken warp 24.5% and thick weft 21.2%. Improvement proposals are given to the highest percentage of defects, namely double weft with the following proposals: Carrying out machine maintenance and replacing the new gun eye so that the gun eye is not blunt, replacing the roller on the worn warping machine with a new roller, providing comprehensive and intensive training to workers on how to use the machine effectively and correctly. It is hoped that this research can help the company improve the quality of the fabric products produced.

Introduction

In the manufacturing and service industries, companies must be ready to face competition in the market in order to compete and survive. One of the crucial elements for the sustainable development of a company is the quality of the products produced. In order for a company to advance or continue to exist in the industrial world, the company must be able to provide high-quality goods or services that are in accordance with the needs and desires of consumers and maximize the use of resources to achieve that goal (Ramlawati & Kusuma, 2018, Sanny et al., 2021). Thus, improving quality will lead to a decrease in the level of damage to a product (Wicaksono, 2019; Alam et al., 2021; Balasubadra et al., 2024; Liu et al., 2022).

PT. XYZ is a company that focuses on the woven fabric manufacturing industry. The company that operates in the weaving sector was established through joint cooperation from all batik cooperatives in Indonesia. The production process of grey fabric in the weaving unit generally goes through several steps, namely preparation, weaving, and assessment (Islam et al., 2024; Solis et al., 2024; Kumar et al., 2021). However, in its production process, the company faces a number of problems, including the level of defective fabric products. Factors that cause product defects can include aspects of production, raw materials, machinery, equipment, and human resources (Chukwunweike et al., 2024; Mardiani et al., 2024; Arifin et al., 2021). Some triggers for product defects include factors of less careful human resources, raw materials that do not meet standards, and other factors. Based on the results of

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observations, several types of defects were found such as double weft (PD), loose weft (PR), thick weft (PT), and broken warp (LS).

Based on the research results, the amount of fabric production in June reached 40,322 meters, in July 38,466 meters, in August as much as 48,211 meters, in September 57,155 meters, in October it was recorded at 17,532 meters, and in November 32,691 meters. Meanwhile, the amount of defective fabric in June was 5,185 meters, July 4,316 meters, August 5,875 meters, September 7,047 meters, October 1,782 meters, and November 4,038 meters. The total fabric production from June to November 2024 reached a total of 234,377 meters. The amount of defective fabric from the entire period was 28,513 meters, with a percentage of defects reaching 12.1%, which exceeded the failure limit set by the company of 3%.

Based on the problems faced, research was conducted to control the quality of fabric products at PT. XYZ. This research uses the Statistical Quality Control and Failure Mode and Effect Analysis methods. The goal is to determine the quality of fabric products and help companies overcome existing problems. The right solution is expected to be given to the company so that fabric product quality problems can be resolved through Product Quality Control.

Quality Control

Quality control is a planned activity and technique designed to achieve, maintain, and improve the quality of products and services, ensuring they conform to existing standards and meet customer satisfaction (Harahap et al., 2018; Wang et al., 2023).

Statistical Quality Control (SQC)

Statistics is a tool used for decision making in the process and analyzing information contained in a sample. This statistical method plays an important role in ensuring quality. Statistical Quality Control is one of the statistical methods used to collect and analyze sample inspection data in product quality monitoring activities (Escobar et al., 2021; Alzoubi et al., 2022; Dutta et al., 2021; Kovacova & Lăzăroiu, 2021). In SQC, samples are taken from the population and conclusions are drawn based on the characteristics of the sample statistically (Hangesthi & Rochmoeljati, 2021; Ishak et al., 2020; Haider et al., 2017; Westgard et al., 2018; Ayenigba & Ajao, 2025; Hagutin et al., 2022).

Histogram

A histogram is a useful tool for determining variability in a process. It displays data in the form of a bar chart arranged by size or value. The data table displayed in a histogram is commonly known as a frequency distribution (Akbar, 2018; Talukder et al., 2024; Pinkovetskaia et al., 2021).

Pareto Diagram

Pareto diagram is a bar graph in which each type of data is compared to the overall total. Pareto diagram can be used to determine which problems are the most dominant and to assess priorities in solving a problem. In addition, Pareto diagram is also useful for identifying 20% of defects that cause 80% of all defects in the manufacturing process (Lestyánszka Škůrková et al., 2023).

Process Diagram

Flowcharts serve as a visual aid that provides a sequence of operations that must be performed to complete a task. This process diagram is an important first step in understanding various processes, both in administration and manufacturing (Helo & Hao, 2022).

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Scatter Diagram

Scatter diagrams are a tool that can be employed to analyze existing data or information that has already been processed, serving as a means for deeper analysis to establish whether the current causes influence quality characteristics. Also referred to as scatter plots, these diagrams help in determining the relationship between two variables (Andri, 2020; Barat et al., 2022; Barat et al., 2022).

Control Chart

A control chart is essentially a visual instrument for overseeing and evaluating if an activity or process is within statistical quality control limits. Its purpose is to identify issues and enhance quality. The chart includes a central line representing the average value of the process quality traits when they are under control, known as the center line (CL). Additionally, it has two other horizontal lines, referred to as the upper control limit (UCL) and the lower control limit (LCL) (Hairiyah, 2022).

Fishbone Diagram

A Fishbone diagram, also referred to as a cause-and-effect diagram, is utilized to display the fundamental elements (root causes) and the quality features (effects) that stem from these elements. This diagram visually represents the connection between a process's quality and its numerous causal factors (Sulaeman dalam Farchiyah, 2021).

Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effect Analysis (FMEA) is a systematic approach designed to detect and impede numerous potential failure modes. The goal of FMEA is to pinpoint the origin and fundamental cause of quality issues (Wirawati, 2020). This FMEA process involves calculating the Risk Priority Number (RPN) to lessen failure risks by decreasing Severity and Occurrence while enhancing Detection capabilities (Handayani & Yusuf, 2022).

Methods

The current survey was conducted in the production plant of PT. XYZ is a Taiwanese based textile producer dealing with production of woven gray fabrics. PT. was formed as a consortia of national batik cooperatives. The structure of XYZ is a centralised location of production. Weaving unit: the data were collected in the weaving unit where the whole process of fabric production takes place. The unit is composed of consecutive steps (warping, sizing, drawing-in, weaving, inspecting and folding) which altogether defines the whole woven fabric manufacturing process. The choice of the area where the investigation was carried out was supported by the fact that it is the major nexus of the production output and the product-quality issues, thus offering an ideal environment of implementing the methods of statistical quality evaluations and performing the failure analysis.

All fabrics by PT made up the population of the investigation. The weaving unit of XYZ during June to November in 2024. In particular, the sample included monthly production output, as well as all the recorded cases of faulty fabric. The company had internal quality checks which identified defects which were categorized under a pre-decided system into four main defects, namely, the defects of the double weft (PD), loose weft (PR), thick weft (PT), and broken warp (LS). The reasons why these categories were chosen include the fact that they are common and able to influence the product usability and customer satisfaction.

A purposive sampling approach was to acquire data based on the study that will focus on the most relevant information in regard to quality-control goals. Thesix months study- June to November 2024, was involved in data collection. The time range of the research was chosen in order to cover as wide a variety of manufacturing operations as possible and to trace any visible trends in defect patterns throughout several manufacturing runs. The selected span

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included six different monthly runs which resulted into a total amount of fabric given off 234,377 meters and 28,513 meters which were deemed faulty. Such a powerful set of data was found adequate in order to perform serious Statistical Quality Control (SQC) evaluations as well as associated Failure Mode and Effect Analysis (FMEA).

The observational strategy was carried out through the use of documents to collect data. PT maintained internal production and quality control of records which was used as the principal source of data. XYZ that provided the comprehensive record of every month volume of output with the number of fabric that had been affected by every type of defect. The data was gathered in form of numbers and was verified to be complete and internally consistent with the quality control team of the firm. No interventions of any sort were implemented, rather naturally existing production numbers were used to maintain authenticity and relevance of operation.

In order to manage data, the use of standard recording sheets and electronic spreadsheets were created to list down monthly production values and the related number of defects. These tools facilitated the organization of defects classes and led to the calculation of defect percentages and frequencies distribution. The sheets were made to record absolute values of defective meters and proportional relations between the volume of production and the level of defects thus fulfilling the need to have required foundation in order to carry out further statistical analysis of the data obtained.

To move the research to the analysis step, a package of research instruments was used. The various tools of Statistical Quality Control (SQC) that were used consisted of histograms, Pareto diagrams, process flow diagrams, scatter plots and p-control charts. These tools were chosen because of their capability to visualize and interpret the pattern of defects distribution, process dynamics of production and control boundaries. To investigate deeper into the causes, the study has also included Fishbone (Ishikawa) diagram to trace the root causes of the severe defects with special focus on double weft error, which came out to be the most common. This was followed by the Failure Mode and Effect Analysis (FMEA) method in order to assess the severity, occurrence, and detectability of individual failure mode. This was achieved by use of calculation of the Risk Priority Number (RPN) which then gave a quantifiable basis of prioritizing corrective actions. The analysis procedures led to use of spreadsheet softwares that could allow the system to perform the needed statistical computations and graphical displays such that data visualization was used in aid of diagnosis or decision-making.

Results and Discussion

Data on the amount of production and the number of fabric defects were obtained from the company in the form of internal data on fabric production results and data on fabric defects that did not pass company standards. Table 1.1 shows data on the amount of production and data on the number of fabric defects during the period from June to November 2024.

Table 1. Data on Production Quantity and Fabric Defects at PT. XYZ

No	Month	Production Quantity (Meters)	Types of Disabilities (Meters)				Number of Defects (Meters)
			Double Weft (PD)	Loose Weft (PR)	Thick Weft (PT)	Broken Warp (LP)	
1	June 2024	40.322	1.579	1429	998	1179	5.185
2	July 2024	38.466	1.325	593	862	1536	4.316
3	August 2024	48.211	1.396	2258	1148	1073	5.875
4	September 2024	57.155	1.863	1922	1617	1645	7.047
5	October 2024	17.532	587	365	296	534	1.782

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6	November 2024	32.691	1.147	1036	1116	1009	4.308
Total		**234.377**	**7.897**	**7.603**	**6.037**	**6.976**	**28.513**

Source: PT. XYZ

In this study, the data processing used is the Statistical Quality Control (SQC) method and continued with analysis using Failure Mode and Effect Analysis (FMEA). CTQ determination is carried out for attribute characteristics. Each product has different quality characteristics according to the established standards. Fabric products produced by PT. XYZ have their own quality characteristics that have been determined by the company.

In the past six months of 2024, PT. XYZ has produced 234,377 meters of cloth, but also experienced 28,513 meters in defects throughout the production process. The high defect rate impacts the quality of fabric at PT. XYZ, making it less than optimal. This situation disrupts production levels each shift, potentially decreasing the overall volume of fabric that the company can fulfill.

Based on the data in Table 1, there are four types of defects in fabric production at PT. XYZ those are double weft, loose weft, thick weft, and broken warp. These defects are the most frequently occurring in the company, impacting the quality of fabric production. However, this study specifically focuses on double weft defects, as they have the highest occurrence in the production process.

Histogram

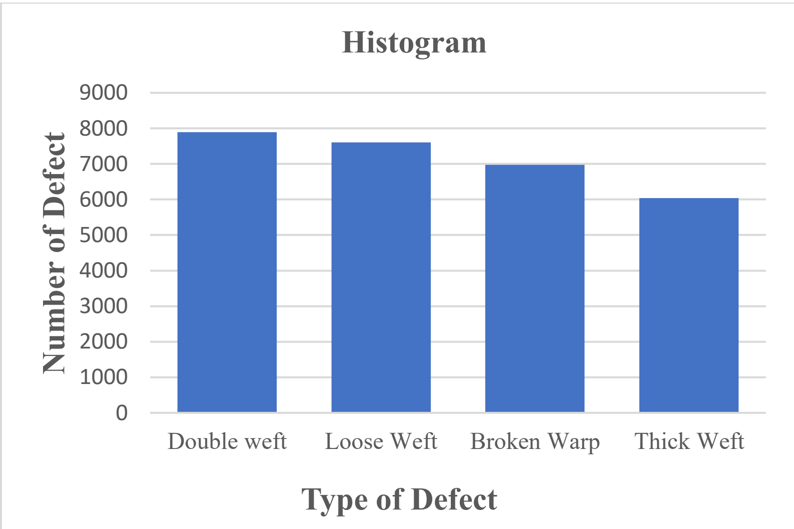

Figure 1. Histogram of Fabric Products

Histogram is one of the SQC tools that is useful for analyzing the distribution of data. Based on Figure 1.1 above, it can be seen the sequence of defect type intervals that have the highest to lowest values, including: Double weft as much as 7.897 meters, loose weft as much as 7.063 meters, broken warp as much as 6.976 meters, and thick weft as much as 6.037 meters.

Pareto Diagram

Pareto diagram is a method for managing errors or defects to help focus attention on problem solving actions. By using a Pareto diagram, the priority of problems that must be resolved can be seen so that the priority of problem solving can be known.

Table 2. Percentage of Defects in Fabric Products

Type of Defects	Number of Defects	Percentage (%)	Cumulative Percentage (%)

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Double Weft	7.897	27,7	27,7
Loose Weft	7.603	26,7	54,4
Broken Warp	6.976	24,5	78,8
Thick Weft	6.037	21,2	100
Total	**28.513**	**100**	

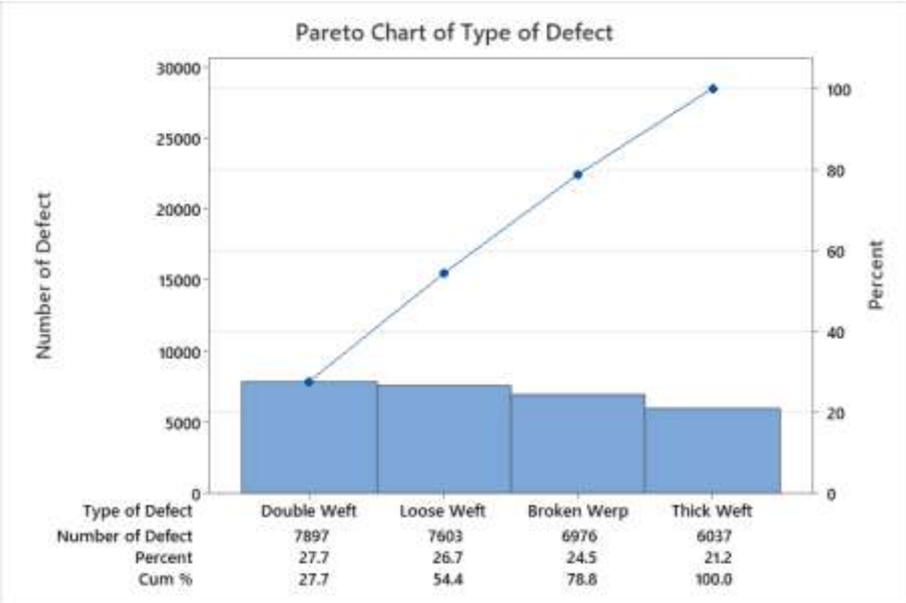

Figure 2. Pareto Diagram of Fabric

Based on Figure 1.2 above, a Pareto diagram of fabric product defects can be seen. Where the highest type of defect is Double Weft with a percentage of 27.7%, followed by Loose Weft which has a percentage of 26.7%, then Broken Warp with a percentage of 24.5%, and finally the lowest defect is Thick Weft with a percentage of 21.2%. From this percentage, it is evident that double weft defects have the highest occurrence, leading to major fabric defects that render the fabric unusable. On the other hand, broken warp defects have the lowest percentage, indicating that the production defects are minor, allowing the fabric to still be used after undergoing a sorting process.

Process Diagram

Process diagram is a statistical Quality Control tool that functions to provide an overview of the production process and also to explain the steps in making a product. The steps in making fabric can be seen starting with the warping process. This is the stage of rolling the warp yarn from cones into beam warping rolls. After the warp yarn has been successfully inserted into the beam roll, the sizing stage is carried out. This involves coating the warp yarn with a starch solution to increase the weaving power during the weaving process. Then, in the drawing in process, the warp yarn is inserted into the dropper, gun eye, and weaving comb according to plan with the help of a reaching machine. The next stage is the weaving stage, where the warp yarn and weft yarn are crossed, as the core of making fabric. After that, the inspecting process is carried out to check and improve the quality of the finished fabric. Finally, there is the folding process, which is folding the fabric while measuring the actual length of the fabric. The fabric is then stacked according to consumer orders and sent to customers or to the finishing process.

Scatter Diagram

Scatter diagram, or scatter diagram is a statistical tool used to show the relationship or correlation between two indicators related to a characteristic. In the weaving process, types of defects found, namely double weft.

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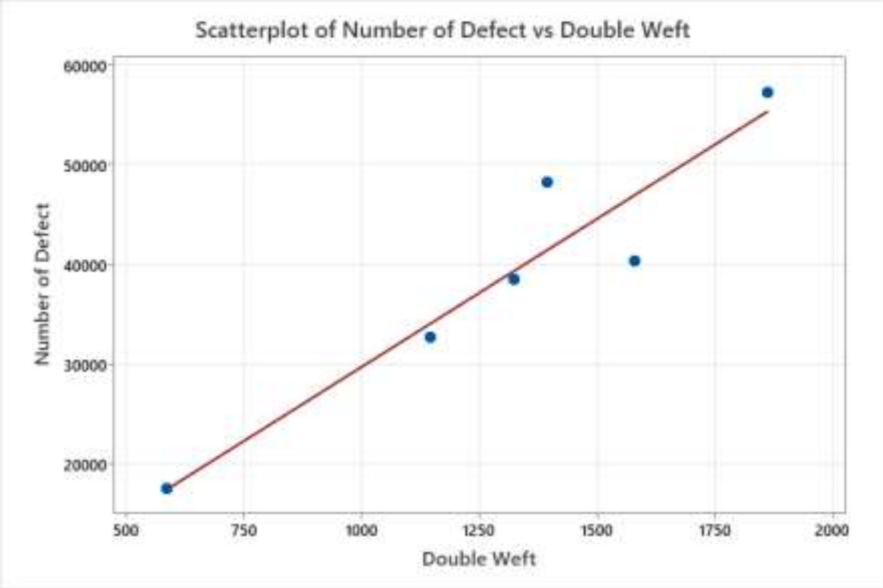

Figure 3. Scatter Diagram of Double Weft Production Results

Based on Figure 3 above, it shows that the regression line has a direction from left to right with the position of the points around the regression line so that there is a positive relationship between the production results variable and the double weft variable, based on the graph it can be concluded that the higher the fabric production results, the higher the occurrence of double weft defects.

Control Chart

The function of the attribute control chart is to determine if defect data falls within acceptable limits, enabling an analysis of product defects. The P control chart is applied in this context to illustrate the parts that are rejected as they do not meet the tolerance limits set by the production quantity. During the weaving process, double weft.

$$P1 = \frac{np1}{n1} = \frac{1579}{40322} = 0{,}03916$$

$$\bar{p} = \frac{\sum np}{\sum n} = \frac{7897}{234377} = 0{,}033694$$

$$UCL = \bar{P} + 3\,\frac{\sqrt{\bar{P}\,(1-\bar{P})}}{n} = 0{,}033694 + 3\,\frac{\sqrt{0{,}033694(1-0{,}033694)}}{40322} = 0{,}036389$$

$$LCL = \bar{P} - 3\,\frac{\sqrt{\bar{P}\,(1-\bar{P})}}{n} = 0{,}033694 - 3\,\frac{\sqrt{0{,}0{,}033694\,(1-0{,}033694)}}{40322} = 0{,}03099$$

If the value of the proportion of defects of a subgroup is above the UCL or below the LCL, it will be counted as data that is out of control.

Table 3. Results of Double Weft Attribute Control Chart Calculation

Month	Total Production	Double Weft	p	p̄	UCL	LCL
June 2024	40.322	1579	0.039160	0.033694	0.036389	0.030998
July 2024	38.466	1325	0.034446	0.033694	0.036454	0.030934
August 2024	48.211	1396	0.028956	0.033694	0.036159	0.031228
September 2024	57.155	1863	0.032596	0.033694	0.035958	0.031429
October 2024	17.532	587	0.033482	0.033694	0.037782	0.029605
November 2024	32.691	1147	0.035086	0.033694	0.036687	0.030700
Total	**234.377**	**7.897**	-	-	-	-

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Based on the calculation results in table 3, the P attribute control map for double feed defects is obtained below.

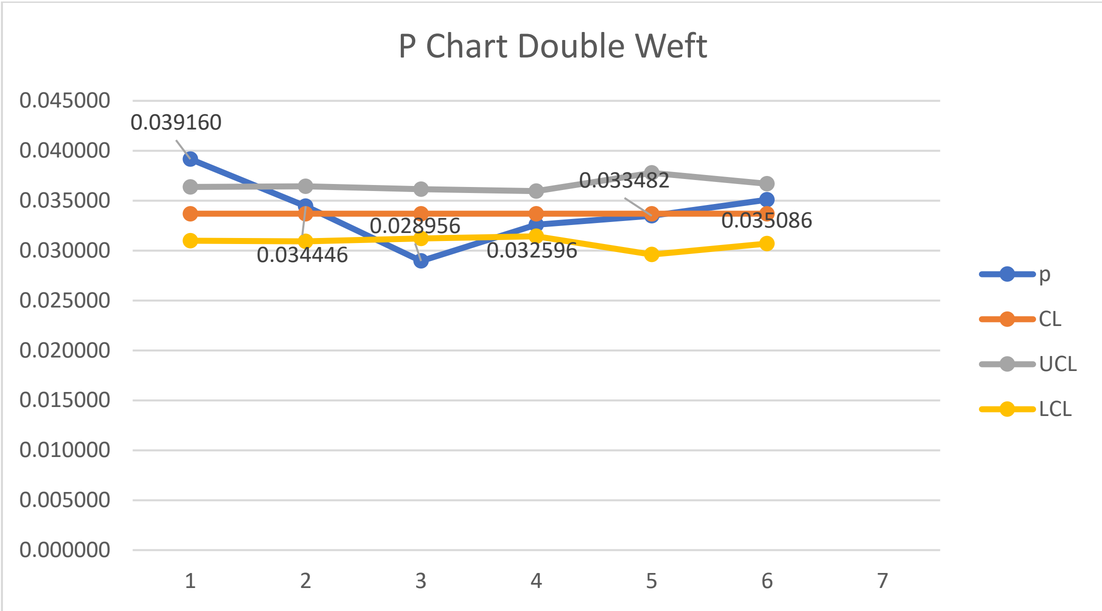

Figure 4. Double Weft P Control Map

Based on Figure 4, it is known that in June to November 2024 there is a value of the proportion of defects outside the control limits, namely in June 2024 it is positioned above the UCL line, in August 2024 it is positioned below the LCL line. This shows that there are still types of defects that are outside the control limits caused by abnormal variations during the process which can be influenced by several factors.

Fishbone Diagram

Fishbone Diagram is a statistical tool used to find out the causes of a type of defect. The cause and effect diagram is used to identify the most common defect factors in each type of defect. In the Weaving process, there are 2 defects that arise, namely double weft and thick weft.

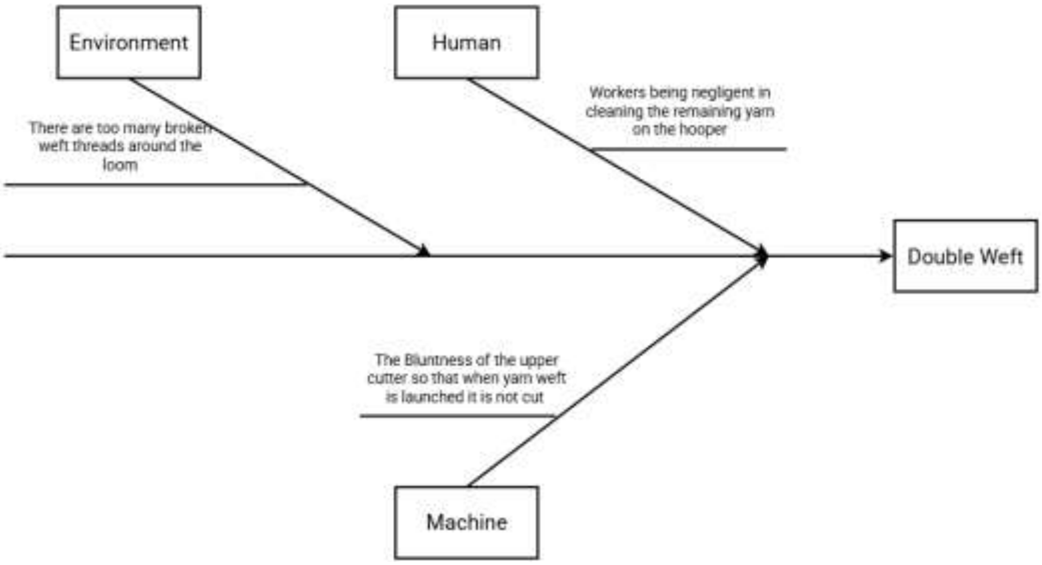

Figure 5. Fishbone Diagram of Double Weft

Based on Figure 5, it can be seen that the causes are reviewed from human, machine and environmental factors.

Man

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The cause of the defect from a human perspective is caused by workers being negligent in cleaning the remaining yarn on the hooper so that when the weft is launched the yarn is carried towards the warp mouth resulting in double weft.

Machine

The cause of the defect in terms of machine factors is caused by the bluntness of the upper cutter so that when the yarn weft is launched it is not cut and is re-launched as wide as the fabric so that it can cause double weft. So workers always check the upper cutter is still sharp.

Environtment

The cause of the defect from an environmental perspective is caused by too much broken weft thread remaining around the loom, causing the remaining thread to enter the shuttle machine, causing the thread to enter the weaving process.

Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effect Analysis is a systematic method used to prevent problems in the production process and products. The use of this method aims to prevent problems or failures in both a product and a process. This stage is a stage of improvement strategy for identification from the results of the fishbone diagram.

Table 4. FMEA of Fabric Products Weaving Process

Modes of Failure	Effect of Failure	S	Cause Of Failure	O	Current Control	D	RPN
Double Weft Defect	This causes the fabric product to have weft threads that pile up in the direction of the width of the fabric during the weaving process. If this can still be repaired, repairs will be made by the operator, which will result in excessive labor and a decrease in the quality of the company's fabric.	4	Too many broken weft threads around the loom cause the remaining threads to enter the shuttle machine, causing the threads to enter the weaving process.	5	Workers often clean up the remaining yarn according to shifts or schedules around the loom routinely so that the shuttle machine area is clean from remaining yarn.	4	80
			On the shuttle machine, there is an upper cutter that is not sharp enough, so when the weft is launched, the yarn is not cut and is launched again as wide as the fabric, which can cause double weft.	6	Always check the shuttle machine, especially the upper cutter, replace the upper cutter with a new one to keep it sharp.	5	120

Based on the results of data processing using statistical quality control (SQC), the highest defects using the Pareto diagram are double weft defects, then loose weft defects, followed by broken warp defects, and finally thick weft defects. The relationship between the four types of defects and fabric production on the scatter diagram shows a positive relationship where an increase in the amount of fabric production results in an increase in the number of four types of defects. On the P attribute control chart, it shows that the four types of defects are out of control so that the cause of the problem is identified and recommendations for improvement are proposed. The cause of the problem of double weft fabric defects in the Weaving process is Too much broken weft yarn around the loom causes the remaining yarn to enter the shuttle machine causing the yarn to enter the weaving process, On the shuttle

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machine there is an upper cutter that is not sharp enough so that when the weft is launched the yarn is not cut and is re-launched as wide as the fabric so that it can cause double weft.

Based on the results of the RPN calculation for the FMEA of fabric products, there are several high priority risks that require quality control proposals to reduce the possibility of failure. One of the problems with the fifth highest RPN value is 120, which is a double weft defect in the weaving process. The cause is the sharpness of the upper cutter on the shuttle machine which has decreased, so that when launching, the weft yarn is not cut perfectly and can be launched again wide on the fabric, causing a double weft which is included in the medium RPN category. Proposed improvements include routine checks on the shuttle machine, especially the upper cutter, and replacing it with a new one to keep it sharp.

Strategic Quality Improvements Based on Defect Characterization and Risk Assessment

The results of the work under consideration point out emphatically that the problem of product quality management within a textile production system cannot be discussed as a linear process or an isolated one. The form and rates of defects and especially the high percentage rate of double weft indicate that the problem lies deeper with the structure of production, routine maintenance and the work ethics of the workers. Although this measurement of defects is very much necessary, what follows is a process of converting these knowledge in terms of taking the right operational decisions that enhance reliability reinforced by minimizations on waste on products.

An occurrence of high-frequency defects repeatedly during two to three months suggests that the existing quality assurance system can be reactive but not preventive. Rather than allowing defects to happen and then being measured, the system is supposed to make predictions and endeavour to stifle the environment that causes the defects (Prunella et al., 2023). This involves the need to move on to defect prevention instead of defect detection. Modern empirical studies, especially those conducted by Akbar (2018) and Hairiyah et al. (2022), show that the synergy between quality control functions and the use of equipment maintenance strategies allows earlier identifying the process of mechanical wear and decreasing its negative impact on product quality. The report also shows that the quality lapses can be reduced through defect-based data trend-based playbooks of preventive maintenance.

Besides, the fact that the majority of defects is concentrated in four groups indicates that a relatively little group of causal factors triggered a significant percentage of total product-related problems. The clustering of the sources of defects indicates the potential approach of specific, as opposed to omnibus, intervention. This is also based on other research including the study by Lestyánszka Škůrková et al. (2023) that has shown that even isolated improvement on the most often reported defects can also result in disproportional increase in product quality. Consequently, PT. XYZ may logically devote resources to eliminating the most common flaw types, starting with the most prevalent like a double weft, whereas, they will see faster and less immeasurable improvements in the product homogeneity and the effectiveness of the process.

The fact that the volume of production is positively correlated with the occurrence of defects leads to another factor of consideration which has to do with the scalability issue. Increased production will place stress on established systems of machine maintenance, employee support and overseeing quality in absence of comparable scaled changes to be implemented. The results of Mardiani et al. (2024) and Wicaksono (2019) recommend corresponding reprofiling of the inspection schedules, the reduction of the machine-tool tolerance, and the amendment of the work/rest ratios in order to overcome the inflictions wrought by fatigue. In the absence of these calibrations, increasing the volume of production can end up compromising the reliability of the products and increasing the levels of waste thus undermining the perceived advantages of increased output.

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Also, there are significant variations of the defect level in various months further showing during the processing data values that lies beyond the limits on the p-chart. The solution to this fluctuation is an important issue involved in long term product uniformity, and process control.

To conclude, the lack of evidence found in the existing literature supports the idea that by focusing on the most prevalent defects, namely, on the double weft, it is possible to provide the swift and measureable improvements in the product uniformity, as well as in the processes proficiency. At the same time, a scaling production mechanism, including rationalized quality checks, finer adjustments of manufacturing tolerances, and precise work and rest pattern, is necessary to ensure maintenance of the product reliability and avoid the wastefulness. The elimination of the variation indicated between months of production would also be supportive to the organizational commitment of never ending quality improvement (Kanitz et al., 2023; Tan et al., 2024). A statistically significant sample of special cause variations in the data set alarms that there is an influence of unexpected incidences, like equipment failure, environmental changes, or human errors to the output. Since the deviation observed is not at random points as would have been the case, the results would indicate unstable operation situation. It is a confirmation of existing evidence offered by Wang et al. (2023) and Talukder et al. (2024), which attempts at concluding that sustained monitoring and prompt fault identification is the key to the maintenance of the process quality. For PT. Active measures like condition-monitoring instrumentation and the installation of sensors would improve the stability of the system and its resilience, XYZ.

Failure Modes and Effects Analysis (FMEA) shows the most crucial failure modes and the areas in which the existing control measures are ineffective. In this case, relatively high RPN value of cutter-related failure mode means that it is a known issue with failure modes mitigation methodologies that are not complete yet. According to Handayani & Yusuf (2022), since control exists and RPN levels are still in the medium to high scale, it is better to redesign rather than to reinforce procedures. In the described scenario, the enhancements could include a switch from current cutter blades to wear-resistant; automatization of the sharpness check to get rid of trusting it to be manually performed. These interventions would be able to prevent recurrence of high-risk failures without impacting negatively on the load of labor.

The general point that comes out after this treatment is that quality control should no longer be limited to the final inspection process but instead it has to be instilled in each stage of production such as the preparation of the yarns, setting up of the equipments as well as evaluation in real time during the weaving process. This finding aligns with that of Islam et al. (2024) and Solis et al. (2024) who postulate that integration of quality in the early phases is necessary when taming Alfes and downstream malfunctions and saving rework and other costs mainly due to rejection of the product. That is why PT is advised. XYZ uses the quality control of discrete milestones on its production lines, admitting fast interventions during process drifts and, therefore, eliminating downstream defects. The results also indicate that despite the fact that human error comprises a significant part of the product imperfection, rare is the case when it can be attributed to negligence, yet far more often can be explained by inadequate design. To illustrate, the presence of waste yarn around the loom is the sign of the lack of specific cleaning procedures and an inadmissible amount of time that is given between shifts to perform housekeeping chores. As it can be found in the literature, operational reliability is enhanced when the human agents perform within well-structured settings that eliminate the repetition of work on repetitive tasks. Therefore, to improve the performance of the workers, it is important to focus on both instructor-based training and the restructuring of the work array to make every activity not only ergonomically but also operationally sustainable.

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The empirical implication indicates that PT. XYZ will need to invest in long-term training programs that should focus not only on developing skills but also on the acquaintance with the mechanisms of defects. As Chukwunweike et al. (2024) remark, integrative programs based on case studies of past defects and their consequences have demonstrated the ability to enhance the decision-making of operators in time-constrained environments. Supplements of these interventions should be complete standard operating procedures and digital inspection checklists as ways of encouraging conformation to laid down routines. What is more, the modern technology should facilitate the shift between the reactive and proactive quality control. Helo & Hao (2022) suggest connecting data-analytics platforms to production equipment to save time, but automated quality inspection alerts or corrective steps that occur based on the quality inspection information obtained. Thus, there will be a closed-loop system, where each production cycle will serve as the reason and interest to associated another one.

Conclusion

Based on research related to the quality of fabric products, four types of defects were found, namely Double Weft (PD), Loose Weft (PR), Thick Weft (PT), and Broken Warp (LS). Data analysis with a Pareto diagram shows that Double Weft is the most dominant defect with a percentage of 27.7%. Furthermore, Loose Weft has a percentage of 26.7%, followed by Broken Warp with 24.5%, and the lowest Thick Weft at 21.2%. Quality control proposals based on the highest RPN value that fall into the medium category include: Carrying out routine machine maintenance and replacing blunt gun eyes, replacing worn rollers on warping machines, providing in-depth training to workers on effective and correct use of machines, additional training on accuracy and techniques to improve work skills, routine checks of shuttle machines, especially on the upper cutter, and replacing the upper cutter to keep it sharp, using high-quality yarn, carefully monitoring yarn storage, and setting quality standards before production. In addition, provide supervision and guidance to workers, instruct them to clean the remaining thread around the shuttle machine and pallet bobbin regularly according to schedule or shift, so that the area remains clean and the weft thread in the pallet bobbin is not woven.

There are suggestions that need to be considered by the company, namely, it is better to carry out more intensive supervision of workers to be more careful and disciplined, the company should provide training in the use of machines to all workers in order to improve the quality of the company's human resources, the company should carry out regular machine maintenance so that the condition of the machine is maintained during the production process. And with the SQC and FMEA methods in this study, the company is expected to be able to consider implementing the recommendations for improvement that have been given in order to control the quality of fabric products.

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