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Enhancing Quality Management and Continuous Improvement Strategies in Polyester Yarn Production Using Lean Six Sigma DMAIC Methodology: A Case Study of PT Logachan Tekstil

Sakti Raj[1], Yuanita Handayati[2]
[1](School of Business and Management, Institut Teknologi Bandung, Indonesia)
[2](School of Business and Management, Institut Teknologi Bandung, Indonesia)
*Corresponding Author: Sakti Raj[1]

ABSTRACT : *The global textile industry faces numerous challenges, including changing fashion trends, increasing consumer demand for sustainability and quality, and intense competition. PT Logachan Tekstil, an Indonesian textile manufacturer, is aiming to improve quality control through the Lean Six Sigma DMAIC methodology. The study identifies the root causes of defects in polyester yarn production, affecting customer satisfaction and sales. Tools like Fishbone Diagrams, Pareto Charts, and FMEA are used to analyze the process. Key findings reveal issues like inadequate training, inconsistent quality control practices, and equipment maintenance lapses. Solutions include comprehensive training, standardized inspection processes, advanced data analytics, and improved team communication. The study integrates Lean Six Sigma with real-time data analysis to enhance product quality and operational efficiency. Continuous improvement programs, customer feedback mechanisms, and regular audits are recommended to ensure sustained quality and competitiveness.*

KEYWORDS - *Textile Industry, FMEA, DMAIC, Lean Six Sigma*

I. INTRODUCTION

The global textile industry is a continuously evolving field that presents various challenges for businesses operating in it. These challenges include rapidly changing fashion trends, rising consumer demand for sustainability and quality, and intense global competition. Textile is a process or activity of making fabrics by knitting or weaving yarn, produced from fibers which then the fabric can be used and patterned according to demand, such as in sewing to the dyeing process to be given color [1].

The textile industry in Southeast Asia is experiencing steady growth, driven by factors such as low production costs, abundant labor, and increasing investments [2]. The market is projected to continue expanding, with significant contributions from countries such as Vietnam, Indonesia, and Thailand. The textile industry in Southeast Asia is highly competitive, with major players such as in Indonesia and other large manufacturers in Vietnam and Thailand. These companies focus on product innovation, sustainability, and strategic partnerships to maintain their market position. On top of this, inconsistent quality standards across the region pose a significant challenge.

In Indonesia, the textile industry and textile products (TPT-Tekstil dan Produk Tekstil) is one of the leading sectors that supports the national economy [3]. Indonesia is known as one of the largest textile producers in Southeast Asia, with products ranging from raw materials such as yarn and fabric, to finished products such as clothing and fashion accessories.

In 2021, Indonesia's Ministry of Industry implemented measures to support textile industry growth, including tax incentives, subsidies, and digital transformation. The Indonesian Textile Association (API) analyzed in 2022, aiming to increase domestic market share and focus on innovation and technology, while boosting exports to other countries. These measures aim to mitigate the impact of the pandemic on the textile industry (Indonesian Textile Association) [3].

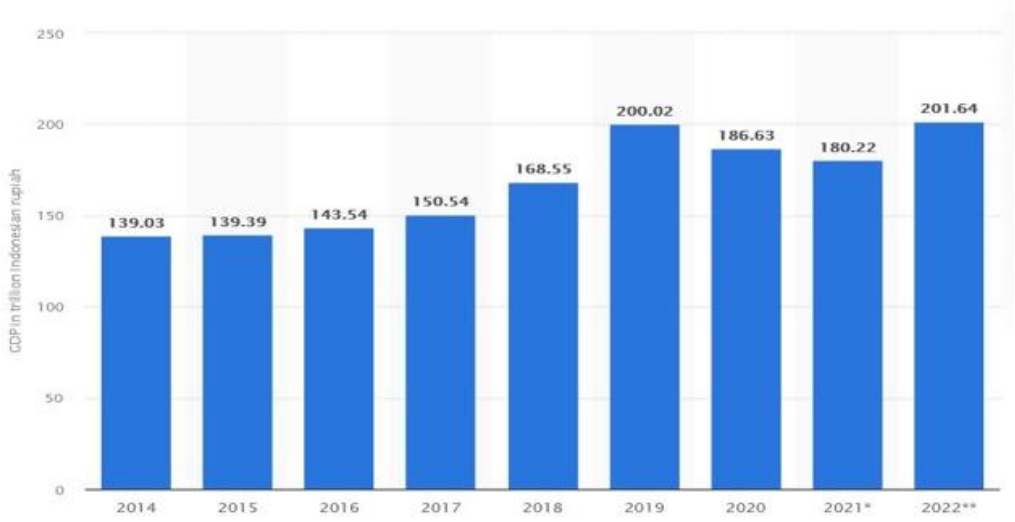


Figure 1 GDP of textiles and apparel in Indonesia from 2014 to 2022

The Indonesian textile market also shows resilience and has great growth potential in the future. As a leading sector that has entered the international market, the Indonesian T&A industry has begun to focus on sustainability issues; however, this study is still limited [4]. Despite facing challenges such as global competition and disruption caused by the Covid-19 pandemic, there are opportunities that can be exploited for the future of the Indonesian textile industry, especially through innovation, focus on sustainability and technological developments that can help maintain excellence, Indonesian textile companies in strengthening position in the global market.

To maintain and improve its competitiveness, Indonesia must focus on product differentiation through quality and innovation. By adopting advanced manufacturing techniques and sustainable practices, to improve its competitiveness, Indonesia must differentiate its products through quality, innovation and sustainable practices. Despite the progress, quality issues such as variability in yarn production remain a challenge. Variability can arise from differences in raw material quality, inconsistencies in the production process, and equipment limitations. Quality control is an important aspect of textile manufacturing, by addressing current challenges and taking the most effective opportunities, Indonesian textile companies can continue to grow and strengthen their position in the global market [5].

PT. Logachan Tekstil, an Indonesian textile company, produces yarn made from chips, converted into polyester yarn (POY), and twisted into PTY yarn using a texturization machine. The company has been committed to quality and innovation since 2008, focusing on good quality control to meet established standards. However, since January 2023, the percentage of defects has increased significantly, reaching 45.7%. This decrease in customer demand is attributed to dissatisfaction with product quality, negatively impacting sales.

PT. Logachan Tekstil reported a decline in customer demand and total yearly sales from 2008 to 2023, primarily due to Covid-19. The company initially experienced stability until 2018, but then experienced a slight decline in sales during 2019-2021. In 2022, sales increased again, reaching up to 34,153 USD. However, in 2023, sales dropped to 28,012 USD and customer demand fell to 87,630 Kg. This decline is likely due to dissatisfaction with product quality, which negatively impacts sales. PT. Logachan Textiles also experienced an increase in incidents after production, including defective yarns that did not meet Total Quality Management (TQM) standards.

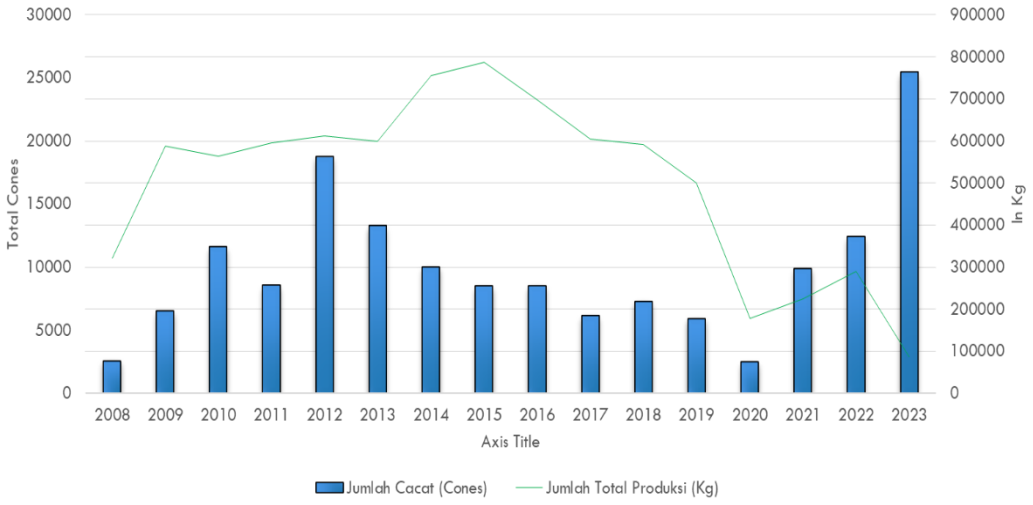


Figure 2 Number of Defective Yarns (Cones) & Total Production (Kg) - Periode '08-'23
(Source: PT. Logachan Tekstil)

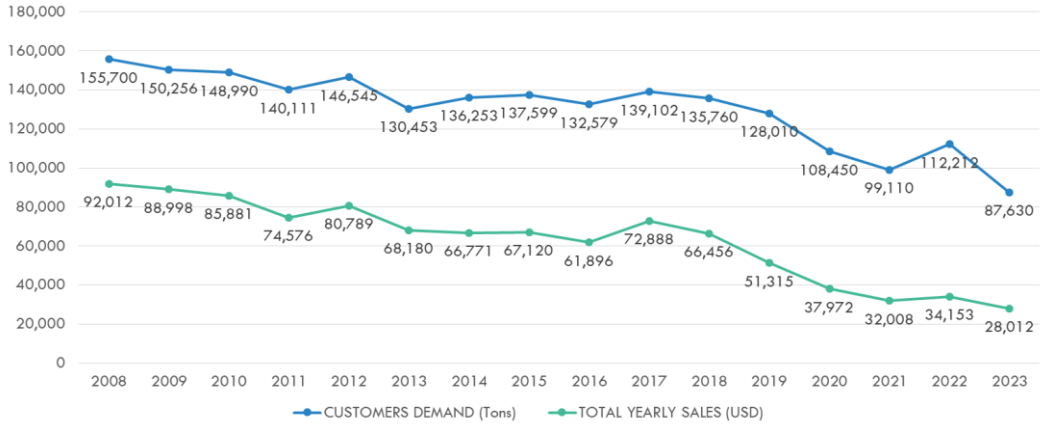


Figure 3 Yearly Sales Based on Customer Demand (Without Product category) - Periode '08-'23
(Source: PT. Logachan Tekstil)

The TQM team conducts random inspections of POY yarns, leading to many being damaged and causing customers to return them. This lack of awareness between the production and TQM teams has created significant gaps in operations, potentially causing a loss of customer trust and sales. Researchers will use the Lean Six-sigma DMAIC methodology to explore quality problems at PT. Logachan Tekstil and implement the Lean Six-sigma DMAIC methodology to improve overall product quality and customer satisfaction.

The research questions of this research are as follows: How can the Lean Six Sigma DMAIC methodology be effectively implemented to improve quality control issues at PT Logachan Tekstil, specifically focusing on the phases of Define, Measure, Analyze, Improve, and Control? And What potential failures and challenges should PT Logachan Tekstil consider in the implementation of Total Quality Management (TQM) solutions to ensure successful and sustainable quality improvements?

II. LITERATURE REVIEW

2.1 Total Quality Management (TQM)

TQM is a continuous improvement program whose purpose is to enhance the organization's ability to deliver high-quality products and services [6]. According to [7] they worked on finding out the relation between TQM practices and Quality performance in an industry, if an organization practices TQM in order to have quality performance, it should include leadership, information analysis, supplier's relation, consumer's focus,

process management, improvement of system and involvement of people. TQM philosophy focuses on meeting the customer requirements, requirements must be met first time and every time, and seeks for continuous improvement [8]. It can be said that TQM is an approach focused on continuous improvement of the quality of goods and services that is realized with the participation of all members of the organization [9].

2.2 Quality

Quality can be defined as the characteristics of a product or service that is designed for specific needs under specific conditions [10]. Quality is one of the factors of a company's success in the business environment, so industry and laboratories must seek constant improvements to meet international standards and requirements in the quality of production [11]. Companies should also strive to provide customers with better or better services, which can be good features, good service, or a better user experience. Quality is the company's responsibility to identify, understand, and fulfill customer needs and wants consistently, both now and in the future. Companies that have high quality can definitely fulfill Consumer satisfaction [12].

Quality refers to the characteristics of a product or service that meets or exceeds the needs and desires of customers. It is a product that meets specific requirements and standards. Quality also impacts price and service, as it helps reduce production costs and increases customer loyalty. Quality also affects the quality of the product or service, which affects its ability to meet customer needs.

2.3 Quality Dimensions

There are 8 Quality Dimensiaon [13], [14]. These tools are very effective in reducing the inefficiency of the process [15]. From authors Douglas C. Montgomery and David Garvin, both authors have similar quality dimensions that are suitable for textile companies that produce polyester yarn goods, but for this research I only chose 4 of the 8 existing quality dimensions, which are: Performance, Features, Conformance to standards, and Perceived Quality.

2.4 Quality Control

According to Ishikawa [16], quality control is a special form of inspection using certain methods used to analyze, collect data, control decisions in the production process to achieve product quality based on predetermined specifications. Quality control is a form of activities associated with the production process, the quality control is a system of verification and maintenance, or the desired progress with careful planning, good use of equipment, continuous checks, and action improvement when needed [17]. This problem can be prevented by controlling or monitoring production quality which is carried out with high responsibility and accuracy to reduce costs and avoid errors or irregularities in production that can harm the factory and consumers [18].

Quality control involves several steps to ensure product quality. These include quality control, which involves thorough inspection and the use of specific methods to analyze and collect data on product quality. Quality control is a comprehensive approach that includes quality control, decision-making in production processes, material quality, and continuous improvement to achieve and maintain product quality.

2.5 Lean Six Sigma

The Lean Six Sigma (LSS) concept is an integration of the two quality management concepts of Lean Manufacturing and Six Sigma that attempts to increase the scope and size of improvement achieved by either concept alone. Together, lean manufacturing and six sigma become stronger and eliminate the shortcomings of each approach [19]. Lean and Six Sigma can be compatible whereby both are of quality management [20]. Six-sigma DMAIC is a benchmark to check the process or product quality, also having ability for improving efficiency and quality of product. Researchers in their studies have confirmed the significant role that lean Six Sigma plays in reducing these problems through the continuous improvement [21] and preserving the quality standards to get rid of the defects through settling specific and rational plans [22]. The lean Six Sigma method was used through (defining, measuring, analysing, improving, and controlling) in order to solve fundamental problem represents in reducing the process variance and (defect ratio) the high ratio correlates with the problem [23].

2.6 FMEA (Failure Mode and Effect Analysis)

The main purpose for performing an FMEA is to prevent the possibility that a new design, process or system fails to achieve, totally or in part the proposed requirements, under certain conditions such as defined purpose and imposed limits. For example, the failure modes effect analysis (FMEA) is considered the standard approach representing a universal quality tool that is typically applied at the design stage of products [24]. Janakiram and Keats [25] found that the FMEA was wellknown useful tool in the design process but it is virtually ignored in most process quality improvement paradigms. For the continous improvements the phase of DMAIC can use FMEA to continually assess the risk of new failure modes, ensuring that the process remains robust over time [26].

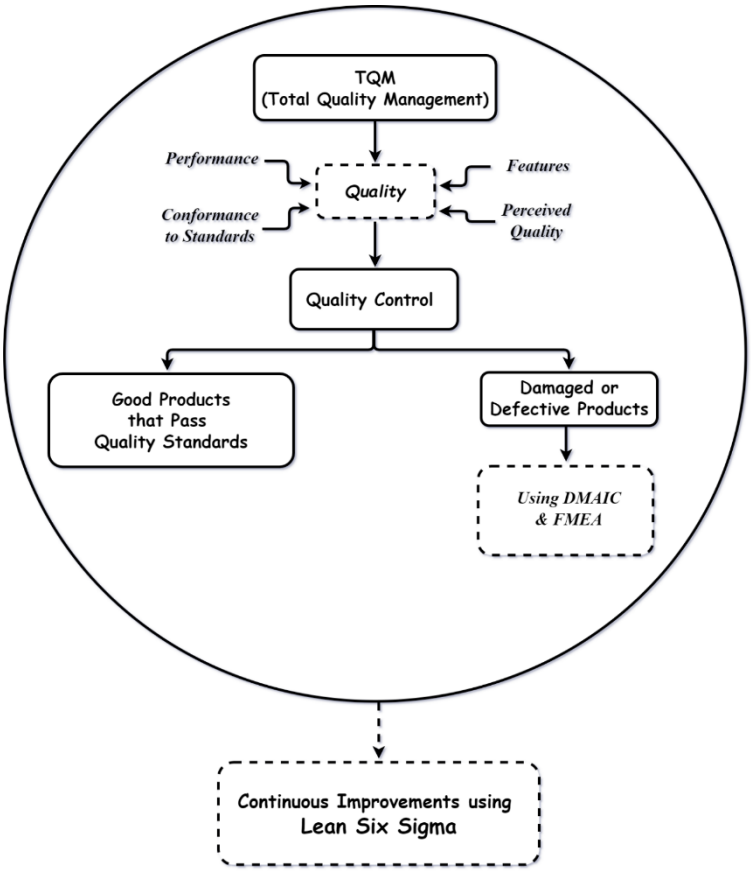


Figure 4 Conceptual Framework - (Source: Author own Analysis)

III. RESEARCH METHODOLOGY

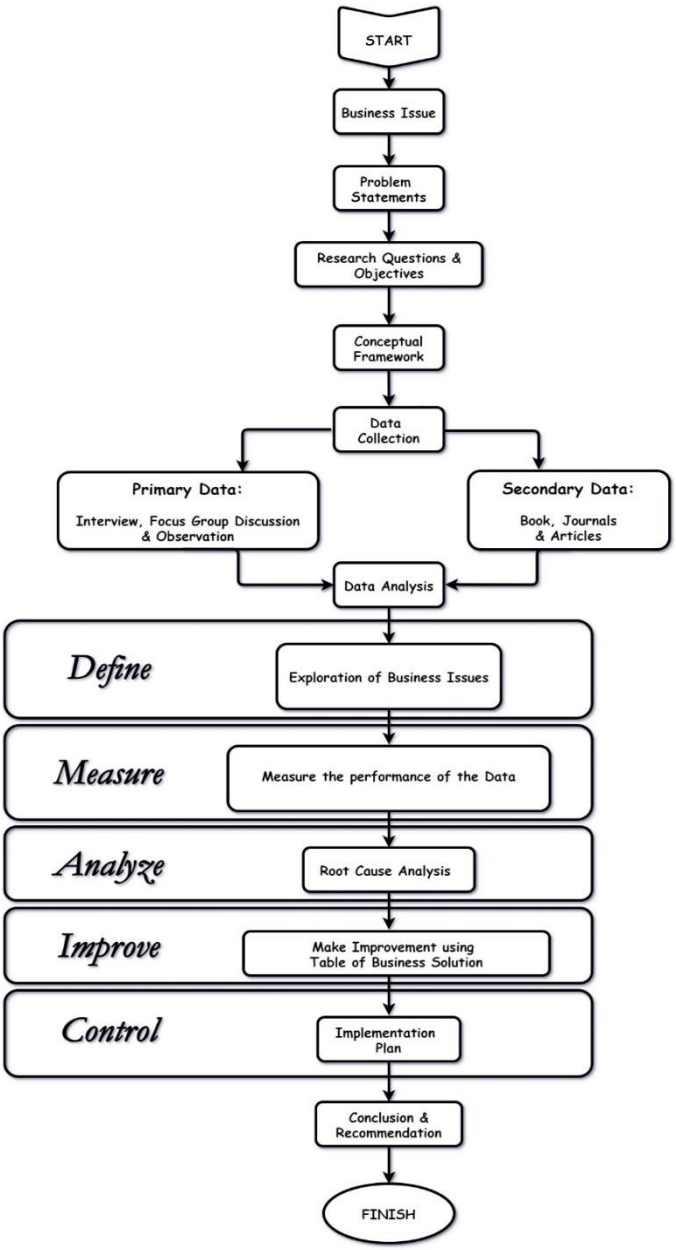


Figure 5 Research Design - (Source: Author own Analysis)

The research methodology for addressing quality control issues at PT Logachan Tekstil involves a comprehensive approach utilizing the Lean Six Sigma DMAIC methodology. Data is collected through qualitative methods like interviews and focus group discussions at PT Logachan Tekstil factory in Surabaya. Secondary data is gathered from literature, company data, and internet sources.

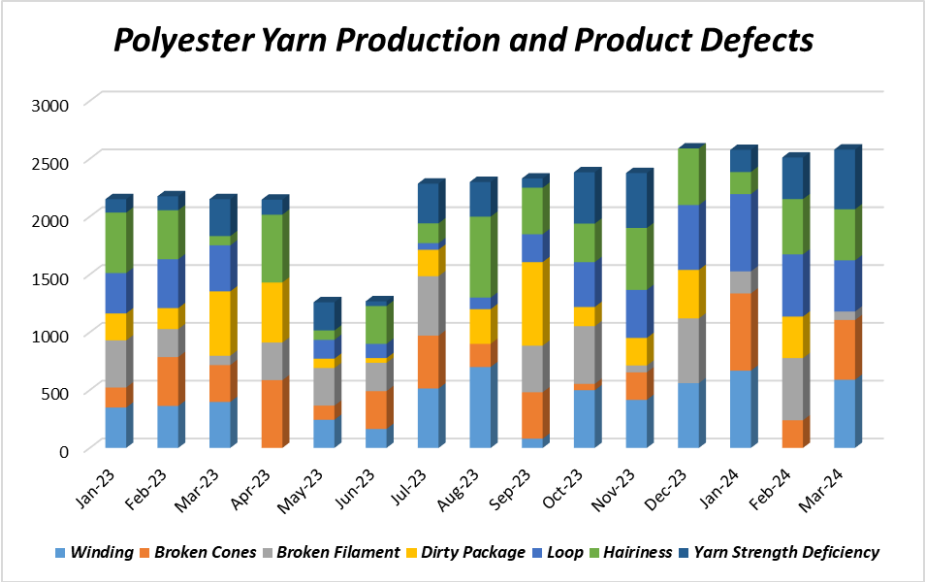
Data analysis follows Lean Six Sigma methodology, starting with Define to identify production process flow and defects. Measurement, Analyze, Improve, and Control stages are used to identify root causes, implement solutions, and ensure continuous improvement. FMEA (Failure Mode and Effect Analysis) to identify the causes of failure/defects thoroughly accompanied by numerical weighting to determine the effects that need to be prioritized for improvement [27]. This methodology aims to improve product quality, reduce defects, and enhance customer satisfaction at PT Logachan Tekstil.

IV. RESULT AND DISCUSSION

4.1 Define Satage (Exploration of Business Issues)

The Define stage of the DMAIC methodology is crucial for identifying key issues, setting objectives, and defining scope. At PT Logachan Tekstil, the business problems include declining product quality, increasing defect rates, and reduced customer satisfaction, leading to declining sales and market competitiveness. The main objective is to improve product quality and regain customer confidence by addressing these core issues. The defect rate at PT Logachan Tekstil has soared, with defective yarn increasing from 26.4% in January 2023 to 45.7% in March 2024. This has damaged the company's reputation for producing high-quality polyester yarn. Moreover, customer satisfaction and sales have decreased due to increasing complaints about product defects, resulting in a decrease in demand and sales. The COVID-19 pandemic has led to complacency among Total Quality Management (TQM) teams, resulting in a decline in strict quality control practices. The TQM team's random inspection approach has been ineffective, leading to defects and customer complaints. A more systematic approach to quality control is needed to ensure consistency and reliability, especially in the eyes of customers. A well-defined metric system increases the efficiency of using quality information by directing the preparation of a data collection and sampling plan [28] and preserving the quality standards to get rid of the defects through settling specific and rational plans [22].

Figure 6 Bar Chart - Polyester Yarn Production and Product Defects PT Logachan Tekstil period (January 2023-March 2024)



4.2 Measure Stage

The Measure stage is a step in the process of improving a business's performance [29]. Six Sigma metrics must be clearly defined and measured in order to clarify goals and make them explicit [30].

DPMO and Sigma Level Measurement,

Measuring DPMO and Sigma Level is crucial for organizations seeking to improve their processes, reduce defects, and enhance overall quality.

Before getting the sigma value, you must first do the calculation to determine DPMO, with the following formula:

$$DPMO = \frac{Number\ of\ Defects}{(Number\ of\ Units\ x\ Defect\ Opportunity)}\ x\ 1.000.000$$

From the DPMO (Defect Per Milion Opportunities) formula above, obtained the DPMO value of yarn taken from January 2023, with a total production of 8150, the number of defective yarns 2151, and with 7 types of defects, then:

$$DPMO = \frac{2151}{(8150\ x\ 7)}\ x\ 1.000.000$$

$$DPMO = \frac{2151}{(57050)}\ x\ 1.000.000$$

DPMO =37703.77

After obtaining the DPMO (Defect Per Milion Opportunities) value in January 2023, which is 37703.77, the next step is to find the value of the Sigma Level, with the formula and calculation below:

$$Sigma\ Level = \left(\frac{normsinv\ (1.000.000 - DPMO)}{1.000.000}\right)\ x\ 1{,}5$$

$$Sigma\ Level = \left(\frac{normsinv\ (1.000.000-37703.77)}{1.000.000}\right) x\ 1{,}5$$

$$\boldsymbol{Sigma\ Level = 3.28}$$

Table 1 Calculation of DPMO and Sigma Level of Yarn Products PT.Logachan Tekstil period (January 2023- March 2024)

No.	Period (Month/Year)	Total Production	Total Defective Products	DPMO	SIGMA
1	January 2023	8150	2151	37703.77	3.28
2	February 2023	8253	2176	37665.96	3.28
3	March 2023	8111	2150	37867.45	3.28
4	April 2023	7335	2147	41815.17	3.23
5	May 2023	7925	1261	22730.96	3.50
6	June 2023	7145	1268	25352.39	3.45
7	July 2023	7120	2286	45866.77	3.19
8	August 2023	7012	2300	46858.45	3.18
9	September 2023	6823	2331	48805.51	3.16
10	October 2023	6756	2385	50431.36	3.14
11	November 2023	6500	2376	52219.78	3.12
12	December 2023	6500	2588	56879.12	3.08
13	January 2024	5815	2576	63284.61	3.03
14	February 2024	5700	2512	62957.39	3.03
15	March 2024	5650	2580	65233.88	3.01
Total		104795	33087	45104.39	3.19

For the measurement of process capability, the calculation of Defect per Unit (DPU), Defect per Opportunity (DPO) and Defect per Million Opportunity (DPMO) for the entire yarn production process from January 2023 to March 2024 is carried out as follows:

Defect per Unit (DPU),

DPU is the average number of defects per unit of product, calculated by dividing the total number of defects by the total number of units inspected.

$$Defect\ per\ Unit = \frac{D\ (Total\ Defects)}{U\ (Total\ Units)}$$

$$Defect\ per\ Unit = \frac{D}{U}$$

$$Defect\ per\ Unit = \frac{33087}{104795}$$

$$\boldsymbol{Defect\ per\ Unit = 0.3157307}$$

Defect per Opportunity (DPO),

DPO is a tool that quantifies the number of defects per opportunity for a defect to occur in a unit.

$$Defect\ per\ Opportunity = \frac{DPU}{O}$$

$$Defect\ per\ Oppurtinity = \frac{0.3157307}{7}$$

$$\boldsymbol{Defect\ per\ Oppurtinity = 0.0451043857}$$

Defect per Milion Opportunity (DPMO),

$$DPMO = DPO\ x\ 1.000.000$$

$$DPMO = 0.0451043857\ x\ 1.000.000$$

$$\boldsymbol{DPMO = 45104.39}$$

Based on the DPMO (Defect Per Milion Opportunities) value above, the Sigma Level for the entire production process of yarn products from January 2023 to March 2024 is 3.19 sigma.

Pareto Diagram, also known as a Pareto chart, is a chart that uses bars and a line graph to highlight the most important factors among a large set of factors. The Pareto diagram serves to find out the source of the

most frequently encountered defects or product defects or the types of defects that occur most often so that it can help companies identify the causes of the biggest defects to make improvements [31]. By analyzing and visualizing data, they facilitate effective decision-making and resource allocation, making them a valuable tool for enhancing efficiency.

By analyzing and visualizing data, they facilitate effective decision-making and resource allocation, making them a valuable tool for enhancing efficiency. From the TQM team's data on the number of yarns that experience defects according to their respective types, it can be seen in the table below, the number of Percentage of defect types in polyester yarn of PT Logachan Tekstil.

Table 2 Percentage of defect types in polyester yarn of PT.Logachan Tekstil period (January 2023- March 2024)

No.	Type of Defective Yarn	Total of Defective Yarns	Cumulatives %
1	Hairiness	5762	17%
2	Winding	5545	34%
3	Loop	4866	49%
4	Broken Cones	4726	63%
5	Broken Filament	4461	77%
6	Dirty Package	4048	89%
7	Yarn Strength Deficiency	3679	100%
	TOTAL	33087	

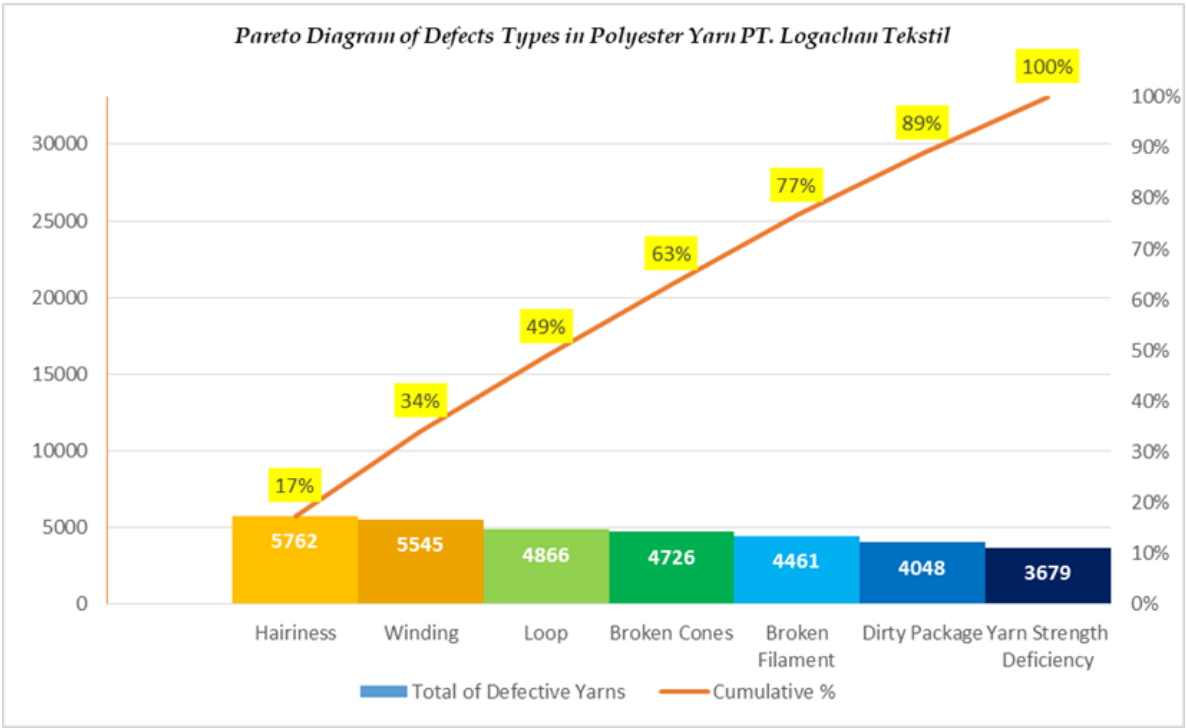


Figure 7 Pareto Diagram - (Source: Author own Analysis and data from TQM team - PT.Logachan Tekstil)

The diagram shows that hairiness type defects account for 17% of total defects, with 20% accounting for 3.4% of the total. Winding type defects account for 34%, accounting for 27.2%. Loop type defects account for 15%, with 20% accounting for 9.6%. Broken cones and broken filament types account for 14% and 11.2% respectively. Dirty package type defects account for 12% and 9.6% respectively. Yarn strength deficiencies account for 11% and 8.8% respectively. The researcher uses the Pareto diagram to identify the most important quality dimensions for improving defective polyester yarn. Based on these dimensions, a mapping table is created based on the types of defective yarn. This helps in identifying and addressing the most problematic types of polyester yarn.

Table 3 Mapping of Defective Thread Types that affect Quality Dimensions

No.	Quality Dimension	Type of Defective Yarn
1	Performance	Yarn Strength Deficiency
2	Conformance to Standards	Broken Filament
		Loop
3	Features	Broken Cones
		Dirty Package
4	Perceived Quality	Hairiness
		Winding

4.3 Analyze Stage

The analyze stage uses data collected to explore the root causes of defects, and to examine key processes to look for non-value-adding activities. It involves steps such as exploring through data and processes, generating hypotheses about causes, and verifying or eliminating causes [32].

Fishbone Diagram, A Fishbone Diagram, also known as an Ishikawa Diagram or Cause-and-Effect Diagram, is a tool used to identify and present possible causes of a problem or effect. It resembles a fish's skeleton, with the main problem at the head and the causes extending out like fishbones.

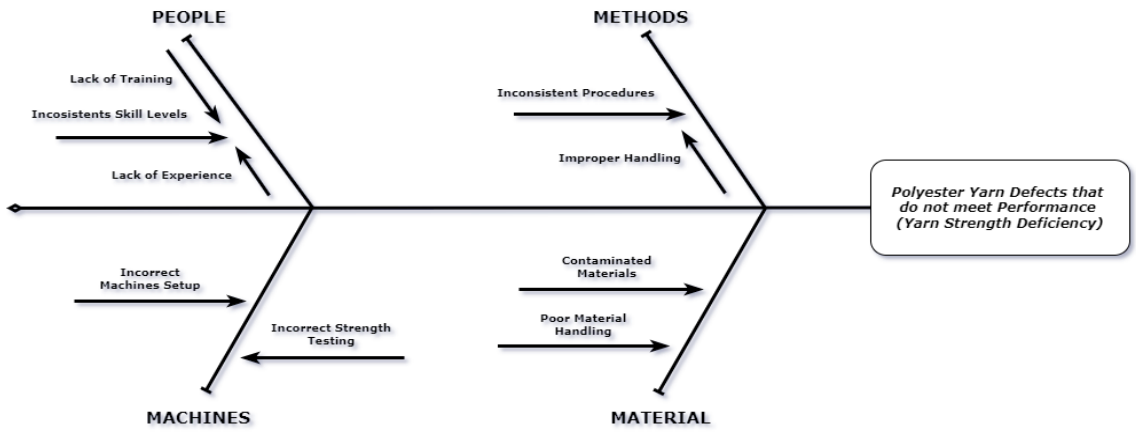


Figure 8 Fishbone Diagram - Polyester Yarn Defects that do not meet Performance (Yarn Strength Deficiency) - (Source: Author own Analysis from TQM team Data – PT.Logachan Tekstil)

The fishbone diagram, also known as an Ishikawa, is a tool used to identify the causes of polyester yarn defects, particularly yarn strength deficiency. It identifies people, methods, machines, and material as the main factors. People can be affected by lack of training, inconsistent skill levels, experience, improper handling, incorrect machine setup, and contamination in raw materials. Machines can be affected by incorrect tension settings or component misalignment. To ensure the quality and strength of polyester yarn, standardized procedures, improved training programs, proper machine setup, and strict quality control are essential.

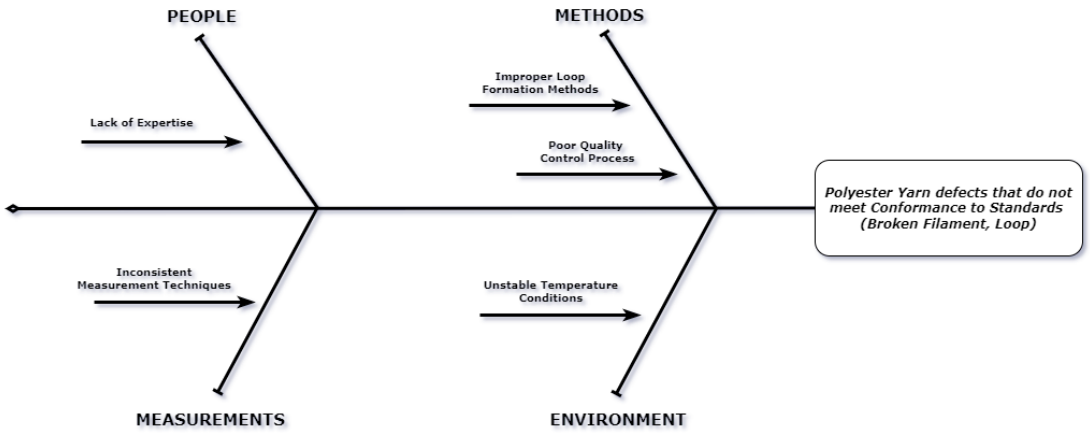


Figure 9 Fishbone Diagram - Polyester Yarn defects that do not meet Conformance to Standards (Broken Filament, Loop) - (Source: Author own Analysis from TQM team Data PT.Logachan Tekstil)

The fishbone diagram identifies three main causes of polyester yarn defects: people, methods, measurements, and environment. People lack expertise, methods use incorrect techniques, quality control processes fail to identify defects early, measurements use inconsistent techniques, and the environment affects yarn properties. To address these issues, the company should improve worker expertise, standardize loop formation methods, improve quality control processes, ensure consistent measurement techniques, and maintain stable environmental conditions.

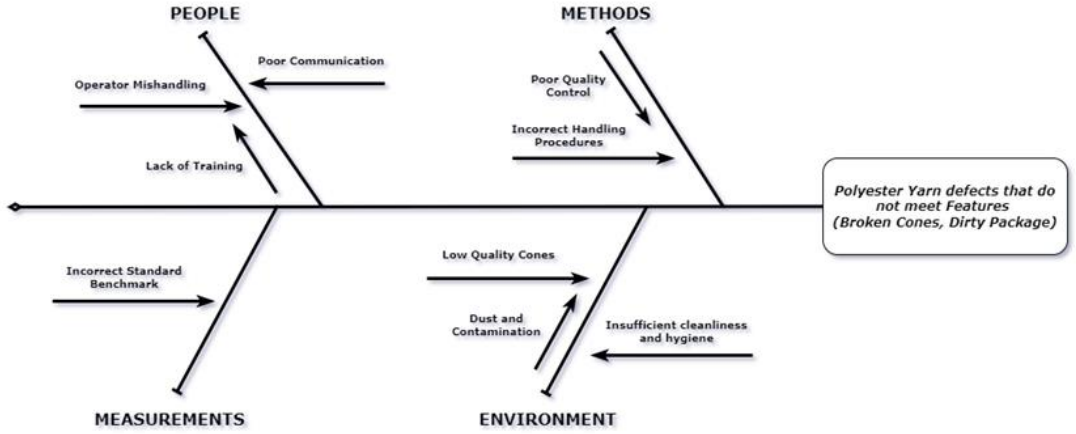


Figure 10 Fishbone Diagram - Polyester Yarn defects that do not meet Features (Broken Cones, Dirty Package) - (Source: Author own Analysis from TQM team Data PT.Logachan Tekstil)

The fishbone diagram identifies main causes of polyester yarn defects, such as broken cones and dirty packages, as operator mishandling, lack of training, poor communication, poor quality control, incorrect handling procedures, low-quality cones, dust, contamination, and insufficient cleanliness. To address these issues, the company should improve operator training, enhance staff communication, strengthen quality control, use high-quality cones, maintain a clean environment, and use accurate benchmarks.

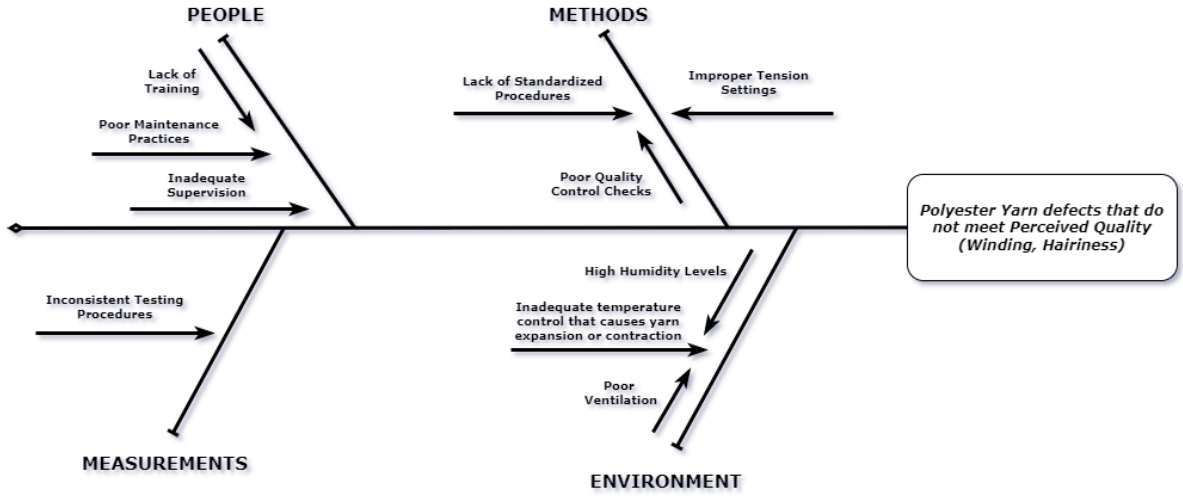


Figure 11 Fishbone Diagram - Polyester Yarn defects that do not meet Perceived Quality (Winding, Hairiness) - (Source: Author own Analysis from TQM team Data PT.Logachan Tekstil)

The fishbone diagram identifies main causes of polyester yarn defects, including people, methods, measurements, and environment. People, such as lack of training, poor maintenance practices, and inadequate supervision, can cause defects. Methods, such as standardized procedures, can cause variability and affect yarn uniformity. Measurements, such as inconsistent testing, can lead to inaccurate assessments. The environment, including high humidity levels and poor ventilation, can also contribute to defects.

To address these issues, companies should enhance training programs, implement regular maintenance schedules, improve supervision, standardize procedures, and maintain optimal environmental conditions.

4.4 Improve Stage

The improve stage performs activities to remove those root causes and to realize improvement. Firms collect and disseminate important quality related data and information through the organization in a timely manner so that problems can be detected and actions can be taken to improve the quality of products and services [33]. Improve phase is the stage of improvement that is used to correct defects that occur while Control is a stage used to evaluate whether the improvements made have succeeded or not [34].

The improve stage is carried out after knowing the root causes of problems from the cause and effect diagram and the priority of proposed improvements, then suggestions for improvements to the problems faced in a company will be given [35], we use tools such as Pareto diagrams, and fishbone diagrams, to ensure a systematic and data-driven approach.

The main purpose of this table is to present a comprehensive and structured business solution that can help PT Logachan Tekstil address product quality issues, improve customer satisfaction, and increase competitiveness in the market. With this planned and evidence-based approach, the company is expected to achieve continuous improvement in its production process.

Table 4 Comparison Table between Existing Business Process and Proposed Business Solution

Existing Business Process	**Issue/Problem Identified (The Root Causes)**	**Proposed Business Solution**	**Expected Benefits**	**Responsible Department**

- While PT. Logachan Tekstil maintains a strong reputation for quality, recent expansion has led to variability in product consistency. - The company has a mix of old and new machinery, with older equipment causing delays and increasing maintenance costs.	Inconsistent procedures, improper handling, incorrect machine setup, incorrect strength testing, contamination in raw materials, Inconsistent measurement techniques, Unstable temperature conditions, insufficient cleanliness and hygiene	- Comprehensive Quality Control Training - Standardize Inspection Processes - Regular Calibration and Maintenance of Equipment - Quality Audits	- Train TQM team on updated quality control standards and practices. - Implement systematic and thorough inspection processes at every production stage. - Develop a checklist for quality control. - Schedule regular maintenance and calibration of equipment. - Maintain a log of maintenance activities and Conduct internal quality audits regularly.	TQM Dept. and Production Dept.
- The company has a diverse supplier base, but lacks strong relationships, leading to variability in raw material quality. - Despite having a capable team, departmental silos lead to delays in decision-making and inefficiencies in project execution.	Lack of training, inconsistent skill levels, lack of experience, lack of expertise, incorrect handling procedures	- Regular Team Meetings - Enhanced On boarding Process - Team Building Activities	- Improved team communication and increased employee engagement - Hold weekly meetings for discussions and collective solutions. - Develop a comprehensive on boarding program and Pair new hires with experienced mentors. - Organize regular team-building exercises and Address interpersonal conflicts promptly.	HR Dept. and TQM Teams

- Although PT. Logachan Tekstil collects significant data, it lacks the tools and expertise to analyze it effectively for process improvements. - Shift to real-time KPI monitoring using dashboards and analytics tools, regularly update KPIs to align with changing goals. - Upgrade to an integrated digital system with real-time data entry, analysis, and IoT devices	Improper loop formation methods, poor quality control process, inadequate supervision, and standardized procedures, can lead to defects	- Develop a Data Collection System - Monitor Key Performance Indicators (KPIs) - Predictive Analytics	- Implement advanced data collection systems for real-time data and Utilize software tools for data analysis. - Identify and monitor KPIs such as defect rates and customer complaints. - Organize Use predictive analytics to foresee potential quality issues. - Implement machine learning models to identify patterns.	TQM Dept., IT Dept. and Production Dept.
- The company has a well-established domestic market but struggles to penetrate new markets due to outdated marketing strategies. - PT. Logachan Tekstil prides itself on customer satisfaction but lacks a formal mechanism to gather and integrate customer feedback into product development.	Poor quality control check	- Customer Feedback Mechanism - Customer Satisfaction Surveys - Continuous Improvement Programs	- Develop mechanisms to collect and analyze customer feedback. - Act on customer complaints promptly. - Conduct regular surveys to gauge customer satisfaction and use survey results for data-driven decisions. - Establish programs like Six Sigma - Encourage employee participation in quality improvement initiatives.	TQM Dept. and Marketing Dept. (Customer Service)

4.5 Control Stage

The control stage in DMAIC is the final phase of the methodology, ensuring the maintenance of improvements made in previous stages. It includes an implementation plan and a control check template to monitor and manage the progress of proposed solutions. The control stage aims to sustain improvements and prevent regression to the original state, ensuring the proposed solutions are effectively integrated into business processes and continuously monitored for desired results. PT. Logachan Tekstil can use a template to control the improvement. The implementation plan relieves the Improve and Control stages, including goals, resources, timelines, and responsibilities, ensuring smooth and effective project execution. It helps organizations identify and resolve potential issues before they become problems.

4.6 Failure Mode and Effect Analysis (FMEA)

By using the FMEA method, it is expected to know what types of defects often occur in yarn products at PT Logachan Tekstil. Based on the data collection made, the next step is to create an FMEA table that provides value weighting using Severity, Occurrence, and Detection to generate a Risk Priority Number (RPN) value [27]. In a mathematical model it can be formulated as follows:

RN = SxOxD

The RPN value is then sorted based on the highest value. The type of product defect that has the highest RPN value is determined as the dominant product defect that occurs in yarn products and needs to be repaired. FMEA is a highly effective and well-established method for identifying, categorizing, and analyzing failures to assess their associated risks. By implementing this method, we can identify failures and avoid their occurrence [36].

Table 5 Risk Priority Category Value of FMEA

RISK PRIORITY CATEGORY	
Urgent Action	***RPN 200+***
Improvement Required	***RPN 100-199***
No Action (Monitor Only)	***RPN 1-99***

Table 6 Table of Failure Mode and Effect Analysis (FMEA)

Potential Failure Modes (Sub-Variable)	***Proposed Solution***	***(SEV)***	***(OCC)***	***(DET)***	***Risk Priority Number (RPN)***	***RPN Rank***
Polyester Yarn Defects that do not meet Performance (Yarn Strength Deficiency)	The TQM team ***conducts regular tensile strength tests to monitor yarn strength*** and make necessary adjustments to the production process to ensure it meets customer specifications.	7	4	5	**140**	**4**

Polyester Yarn defects that do not meet Conformance to Standards (Broken Filament, Loop)	The TQM team ensures high-quality raw materials, ***The TQM team focus on maintaining the integrity of the filaments*** by using appropriate processing techniques and machinery settings. ***The TQM team offers operator training on proper handling techniques and machinery settings to prevent loop defects***, and regularly monitors and adjusts to ensure uniformity in the final product.	6	7	6	**252**	**2**
Polyester Yarn defects that do not meet Features (Broken Cones, Dirty Package)	The TQM team implements handling procedures that ***minimize the risk of cone breakage.*** They ensure that cones are stored properly and handled with care during production and transportation. The TQM team strictly enforces cleanliness protocols in the production area, ***conducting regular packaging inspections*** to ensure the final product meets customer cleanliness standards.	6	6	5	**180**	**3**
Polyester Yarn defects that do not meet Perceived Quality (Winding, Hairiness)	***The TQM team conducts thorough inspections of winding machines,*** ensuring proper calibration, maintenance, and repair, while also providing operator training on proper machine handling and setting adjustments. The TQM team prioritizes machinery cleanliness and lubrication to minimize hairiness***, regularly checking settings and conditions, and training operators to detect early signs of hairiness during production.***	9	8	4	**288**	**1**

FMEA Analysis, Based on data processing results using FMEA, The highest priority is defects related to winding and hairiness, with a RPN of 288, requiring immediate action. The next priorities are defects

corresponding to RPN 252 are defects for broken filaments and loops, The next priority with RPN 180 for defects from damaged features and dirty packaging, the last is a 140 RPN for defects related to yarn strength deficiency.

The highest priority defects identified through FMEA are winding and hairiness, broken filaments and loops, damaged features and dirty packaging, and yarn strength deficiency. These defects directly impact customer perception and product quality.

V. CONCLUSION AND RECOMMENDATION

The study examines the use of Lean Six Sigma DMAIC methodology to decrease high defect rates in polyester yarn production at PT Logachan Tekstil, revealing inconsistencies in quality control, inadequate monitoring, and root cause analysis.

5.1 Conclusion

PT Logachan Tekstil is implementing the Lean Six Sigma DMAIC methodology to improve its yarn production process. The company aims to address declining product quality, increased defect rates, and reduced customer satisfaction, which are contributing to declining sales and market competitiveness. Researchers suggest a more systematic approach to quality control, and Lean Six Sigma plays a significant role in reducing these problems through continuous improvement and preserving quality standards. The company's measurement stage revealed significant gaps in quality control practices, such as random inspections, lack of systematic procedures, and inadequate training of TQM personnel. Comprehensive action plans were developed to address these issues, including enhancing quality control training, standardizing inspection processes, and implementing regular calibration and maintenance of equipment. Advanced data analytics were introduced to monitor key performance indicators and employ predictive analytics for predicting potential quality issues. The control stage involves an implementation plan and control plan template, regular quality audits, and continuous monitoring to sustain improvements.

PT Logachan Tekstil prioritizes defects using FMEA, with winding and hairiness defects being the most critical. Lean Six Sigma methodologies are used to improve product quality and foster a culture of continuous improvement. These methods reduce variability, encourage employee involvement, and maintain continuous improvement through regular monitoring and feedback. However, employee resistance to change is a significant issue, and the COVID-19 pandemic has led to gaps in expertise. Consistent quality control practices, systematic inspections, and regular meetings are needed to address communication gaps within the TQM team. Continuous monitoring, audits, and a robust feedback mechanism are also essential.

5.2 Recommendation

The study suggests several recommendations for PT. Logachan Tekstil to improve its quality control process and product quality. These include Enhance Training and Development, Enhance Communication and Collaboration, Improve communication channels between the TQM team, production staff, and customer service to ensure timely feedback on quality issues and customer complaints, Customer feedback mechanisms are established, and a system is implemented to promptly address complaints, Continuous improvement programs, such as Lean Six Sigma are implemented to encourage a culture of quality and ongoing enhancements.

By implementing these recommendations, PT Logachan Tekstil can achieve significant improvement in the quality of its polyester yarn products, reduce defect rates, and enhance overall customer satisfaction. This systematic and data-driven approach will not only address current quality issues but also ensure continuous improvement and long-term success in the competitive market.

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**Corresponding Author: Sakti Raj[1]*
[1](School of Business and Management, Institut Teknologi Bandung, Indonesia)