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UTILIZING SIX SIGMA TO MINIMIZE DEFECTS IN GAMIS AND TUNICS PRODUCTION AT MOOI CLOTHING LINE

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Abstract

The fashion industry in Indonesia plays a critical role in the country's economy, contributing significantly to employment and creative exports. However, recurring production defects, including uneven seams, fabric tearing, improper sizing, and missing buttons, present significant challenges for garment manufacturers such as MOOI Clothing Line. These quality issues not only increase operational costs through rework and waste but also threaten customer satisfaction and market competitiveness. This research aims to analyze and address the root causes of production defects using the Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) methodology.The study begins with the identification of critical defects at MOOI Clothing Line, where Pareto analysis reveals that uneven seams account for over 33% of total defects, making it the top priority for improvement. Through the Measure phase, Statistical Process Control (SPC) and process capability analysis are employed to assess defect trends and production stability. Results show that MOOI's current sigma level is approximately 3.17–3.55, highlighting the need for process improvement to meet the company's target of reducing defects to a maximum of 2%.Root cause analysis, conducted using Fishbone Diagrams, identifies critical factors such as inefficient workflow systems, lack of standardized quality control procedures, and insufficient operator training as primary contributors to defects. To address these issues, the research proposes an improved production workflow that segments sewing tasks by garment components (e.g., collars, sleeves, body parts), ensuring greater consistency and reducing variability. Additionally, the implementation of interim quality control checkpoints before final assembly enables early defect detection, minimizing rework and production inefficiencies.Further recommendations include enhancing operator skills through structured training programs, implementing robust Standard Operating Procedures (SOPs) for quality control, and introducing systematic defect documentation to monitor recurring issues. By fostering a culture of continuous improvement and leveraging Six Sigma tools, MOOI Clothing Line can significantly reduce defect rates, improve operational efficiency, and enhance customer satisfaction. The results of this research provide practical insights for garment manufacturers facing similar challenges and emphasize the importance of structured quality management systems in achieving sustainable production standards.

Keywords: ***Six Sigma, production defects, quality control, DMAIC.***

I.1 Background

The Indonesian fashion industry is a key part of the economy but struggles with quality defects, affecting profitability and brand reputation. Defects such as misaligned stitching, uneven seams, and fabric issues arise from weak production systems, inadequate worker training, and outdated equipment. Indonesian manufacturers report defect rates up to 8%, higher than global standards, exacerbated by fragmented supply chains. Defects lead to significant financial losses, with global losses reaching up to 15% of revenue. Consumer expectations also push for better quality control, while SMEs often struggle with limited access to advanced technology. MOOI Clothing Line, a prominent local brand, faces these issues, affecting costs and customer satisfaction. Improving quality control is essential for maintaining competitiveness and sustainability in the global market.

I.2 Company Profile

MOOI Clothing Line, based in Bandung, Indonesia, offers stylish and affordable tunics and gamis. Operating in the low to middle fashion market, MOOI serves customers looking for modern, comfortable clothing. The brand operates four stores in Bandung and a strong online presence, reaching a wide range of consumers. MOOI handles the full production process, from design to distribution, ensuring high quality through strong relationships with local and international fabric suppliers. The company emphasizes customer satisfaction and maintains a responsive, flexible supply chain for quick production and delivery.

I.3 Business Issue

MOOI faces recurring quality defects in its production process, such as uneven seams, fabric tearing, and improper sizing. These issues lead to significant costs from material waste, rework, and customer complaints. Defects cause delays in production, reducing overall efficiency and customer satisfaction. While there have been improvements in later months, fluctuations in defect rates remain a challenge. Addressing these issues requires enhanced training, better quality control measures, and a streamlined production process to ensure consistency and reduce defects.

I.4 Research Questions and Research Objectives

Research Questions:

1. What factors cause defects in the production of Gamis and Tunics at MOOI Clothing Line?
2. Which defects have the most significant impact on production?
3. What improvements can MOOI implement to reduce defects?

Research Objectives:

1. To identify root causes of defects using Fishbone analysis.
2. To assess defects' impact on production using Six Sigma's DMAIC methodology.
3. To recommend improvements for reducing defects and improving operational efficiency.

I.5 Research Scope and Limitation

This research focuses on the production of gamis and tunics at MOOI, addressing defects through Six Sigma and Fishbone analysis. The study's limitations include limited access to proprietary data and a focus on MOOI's specific processes, which may not be generalizable to other manufacturers. The research aims to improve production efficiency and quality, reducing defects such as uneven seams and fabric-related issues.

Literature Review

2.1 Problem Exploration MOOI Clothing Line faces challenges in producing gamis and tunics due to quality defects such as uneven stitching, fabric misalignment, and inconsistent measurements. These issues cause material waste, rework, and operational disruptions. Production data shows fluctuating defect rates, with January having 70 defects from 1,034 pieces and December showing improvement with 34 defects from 547 pieces. While improvements have been made, further enhancements in quality control are needed for consistency. Defective garments also affect customer satisfaction, leading to complaints and delays in service, which strains operations and harms brand reputation. The company must prioritize addressing critical defects to improve production efficiency and customer loyalty.

2.2 Total Quality Management Total Quality Management (TQM) focuses on continuous improvement in products and processes by involving all stakeholders. It aims to meet or exceed customer expectations through continuous engagement, with key elements like Six Sigma, Just-in-Time production, and employee empowerment to drive improvements in quality and performance.

2.3 Six Sigma Six Sigma, developed by Motorola, is a methodology that reduces defects through statistical analysis. Aiming for fewer than 3.4 defects per million opportunities, it ensures nearly perfect quality, reducing costs and increasing customer satisfaction. The approach focuses on minimizing variability and enhancing processes to achieve higher quality standards.

2.4 DMAIC Framework The DMAIC framework (Define, Measure, Analyze, Improve, Control) is used to improve processes systematically. It identifies inefficiencies and uses data-driven insights to eliminate waste and enhance performance. The framework is cyclical, emphasizing continuous improvement.

2.4.1 Define The Define phase identifies the problem and its impact on customers, outlining opportunities for improvement. Tools like Pareto charts help prioritize issues by focusing on the most significant defects affecting production and customer satisfaction.

1. **Defect Analysis:** Defect analysis identifies the root causes of recurring issues in production. Tools like Pareto charts help prioritize critical defects, leading to targeted improvements. Studies show that focusing on key defect sources can significantly reduce defect rates.
2. **The Pareto Chart:** The Pareto chart helps organize defects to focus on solving the most significant problems. Based on the Pareto principle, it highlights that 80% of issues often come from 20% of causes.
3.

2.4.2 Measure The Measure phase establishes metrics to assess current performance. Visual tools like Pareto charts and control charts help identify trends and areas for improvement. Statistical Process Control (SPC) monitors process variability, helping identify and correct inefficiencies.

1. **Statistical Process Control (SPC):** SPC uses control charts to track process variability. By distinguishing between common and special causes, it helps identify issues that can be corrected to ensure consistent quality.
2. **Sigma Level:** Sigma levels assess process performance by measuring defects per million opportunities. A higher sigma level indicates fewer defects, with Six Sigma aiming for 3.4 defects per million opportunities.
3.

2.4.3 Analyze The Analyze phase investigates data to identify gaps between current performance and desired outcomes. Tools like cause-and-effect diagrams help pinpoint the root causes of defects, enabling targeted improvements.

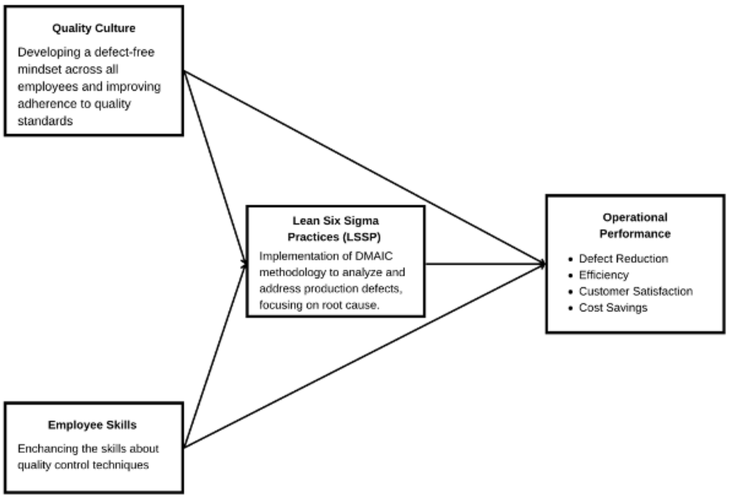
1. **Cause and Effect Diagrams:** Fishbone diagrams help visualize potential causes of defects. By identifying the most significant contributors, organizations can focus efforts on addressing the primary causes.
2.

2.4.4 Improve The Improve phase optimizes processes by eliminating waste and improving flow. Strategies like process mapping and value stream mapping help identify bottlenecks and inefficiencies, leading to enhanced throughput and reduced lead times.

2.4.5 Control In the Control phase, improvements are implemented and standardized to ensure sustainability. Statistical tools monitor ongoing performance to ensure stability, and management systems are adjusted to maintain long-term improvements.

2.5 Conceptual Framework The conceptual framework highlights the relationship between Quality Culture, Employee Skills, Lean Six Sigma Practices (LSSP), and Operational Performance at MOOI. It suggests that fostering a quality-driven culture and enhancing employee skills in quality management enables the effective implementation of Lean Six Sigma practices, leading to improvements in defect reduction, efficiency, customer satisfaction, and cost savings.

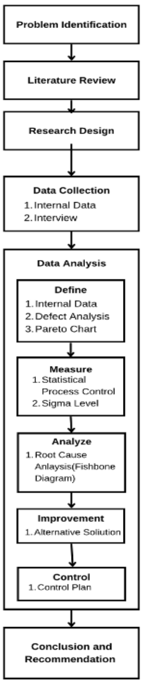
Conceptual Framework



Research Methodology

3.1 Research Flow This research adopts the Six Sigma framework to address quality issues in MOOI's tunic and gamis production. The research flow starts with Problem Identification, where key defects like uneven stitching and fabric misalignment are pinpointed. The Literature Review follows to establish a theoretical foundation, while the Research Design uses a descriptive quantitative case study. Data is collected through internal reports and interviews with key stakeholders. The Six Sigma DMAIC cycle is applied, including Define, Measure, Analyze, Improve, and Control phases. The study concludes with actionable recommendations to optimize production.

Research Design



3.2 Problem Identification Field observations at MOOI helped identify key production defects, including uneven seams and misalignment. The research scope was defined, focusing on quality improvement through addressing these issues.

3.3 Literature Review The literature review led to the selection of Six Sigma, focusing on defect reduction and process efficiency, to address MOOI's production challenges.

3.4 Research Design This study begins by identifying defects like uneven seams and fabric tearing. A thorough literature review and understanding of MOOI's processes set the stage for data collection. Interviews with the Quality Control Manager and Head of Production, along with internal records, help identify defect patterns. The DMAIC methodology is used to analyze defects, improve efficiency, and control processes. Recommendations are made based on findings from the analysis.

3.5 Data Collection Method
3.5.1 Observation The researcher observes the production process and analyzes defect documentation to identify recurring issues and patterns.

3.5.2 Internal Data Analysis Internal reports, defect records, and quality control logs are analyzed to identify defect trends and contributing factors.

3.5.3 Employee Interviews Interviews with key personnel, including the Quality Control Manager and Head of Production, gather insights on defect causes and potential solutions.

3.5.4 Data Analysis Method
3.5.4.1 Define The Define phase involves defect analysis, including a problem statement, goal statement, and project scope. A team is established for the Six Sigma project based on insights from interviews.

3.5.4.2 Measure This phase evaluates current production performance using Statistical Process Control (SPC), Process Capability Analysis (PCA), and sigma level measurements, with tools like Minitab and Six Sigma calculators.

3.5.4.3 Analyze Root cause analysis is conducted using Fishbone diagrams to identify areas for improvement in materials, manpower, methods, and machinery.

3.5.4.4 Improve Improvement solutions are developed based on analysis results, aiming to reduce defects and improve production efficiency.

3.5.4.5 Control In the Control phase, a management plan ensures the sustainability of improvements, with ongoing monitoring and standardization to maintain quality.

4.1 Define In the "Define" phase, interviews with MOOI Clothing Line's management, including the Quality Control Manager and Head of Production, laid the foundation for key activities such as defect analysis, production flow, and Pareto Analysis.

4.1.1 Defect Analysis MOOI Clothing Line has set a maximum defect rate of 2% of total production, making adherence to quality standards essential. Several factors contribute to defects, including uneven seams, fabric tearing, improper sizing, and missing buttons.

4.1.1.1 Uneven Seams Uneven seams are caused by inconsistent sewing techniques due to a lack of standardized processes, fabric issues, misaligned machinery, and inadequate operator training.

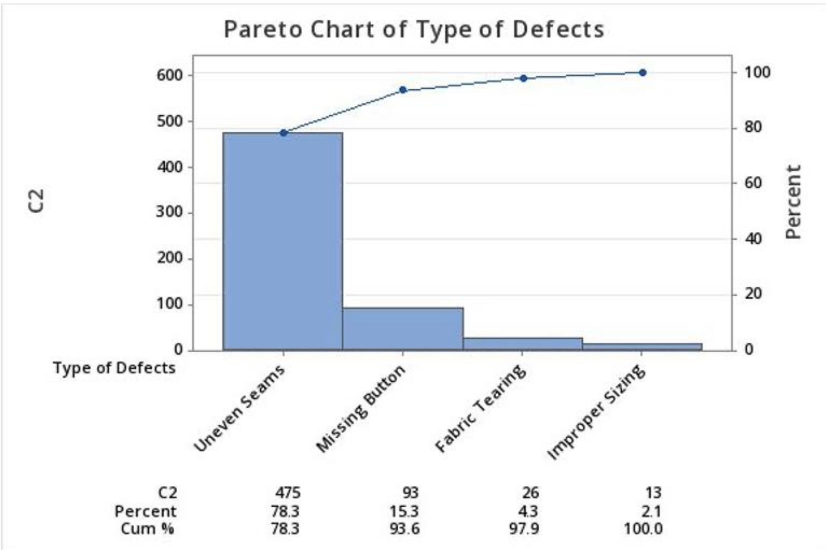
4.1.1.2 Fabric Tearing Fabric tearing arises from poor handling during storage and transportation, fragile material quality, dull cutting tools, and operator errors during the cutting or stitching stages.

4.1.1.3 Improper Sizing Improper sizing results from miscommunication between sales and production, fabric shrinkage, machine calibration errors, and inaccurate pattern placement or cutting by operators.

4.1.1.4 Missing Button Missing buttons are caused by inconsistent quality control checks, poor button thread quality, faulty button attachment machinery, and operator oversight during final inspections.

4.1.2 Pareto Analysis The Pareto diagram was used to analyze defects in tunics and gamis, highlighting the defect types with the most significant impact. Uneven seams were identified as the most frequent defect, accounting for 33.31% of all defects with 3,392 occurrences. While uneven seams and fabric tearing were similar in frequency, fabric tearing was considered less critical, as it is often unavoidable. Since both tunics and gamis are produced in the same process, improvements for one product can be applied to the other.

Pareto Chart of Type of Defects



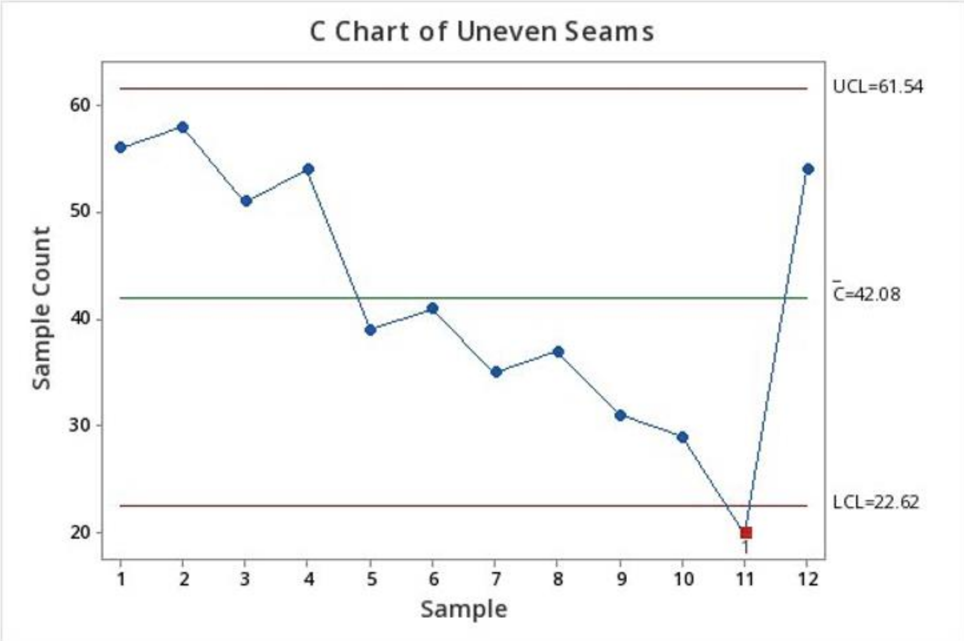
4.2 Measure This phase assessed MOOI's current process using historical defect data from tunics and gamis production.

4.2.1 Statistical Process Control Statistical Process Control (SPC) was used to analyze the stability of MOOI’s process using historical defect data. A C-chart was created to evaluate the stability of the defect count for uneven seams. The chart showed that most data points were within control limits, indicating process stability. However, some variability in the data suggested the need for closer monitoring and improvement efforts.

Defect Sheet

# of Data	Production (pieces)	Defect Types of Gamis & Tunics (pieces)				Defect Products (pieces)	% Defective
		Uneven Seams	Fabric Tearing	Improper Sizing	Missing Button		
1	1034	56	3	1	10	70	6,8%
2	1028	58	4	2	9	73	7,1%
3	1158	51	3	1	9	64	5,5%
4	1247	54	2	2	12	70	5,6%
5	897	39	2	0	8	49	5,5%
6	780	41	2	2	9	54	6,9%
7	694	35	2	1	8	46	6,6%
8	754	37	3	0	0	40	5,3%
9	769	31	4	0	9	44	5,7%
10	612	29	1	1	0	31	5,1%
11	593	20	0	2	10	32	5,4%
12	547	24	0	1	9	34	6,2%
TOTAL	10113	475	26	13	93	607	6,0%

C-Chart of Uneven Seams



4.2.2 Process Capability Analysis A binomial capability analysis assessed whether MOOI's production met its 2% defect threshold. The results showed that the current defect rates do not meet the quality requirements, with Ppk and Cpk values below the industry benchmark of 1.33. The process performance for uneven seams was found to be below target, with a DPMO of 46,969 and sigma levels of 3.17 for tunics and 3.55 for gamis. To meet the company's goal of a 2% defect rate, further process improvements are needed.

Process Capability Report for Uneven Seams

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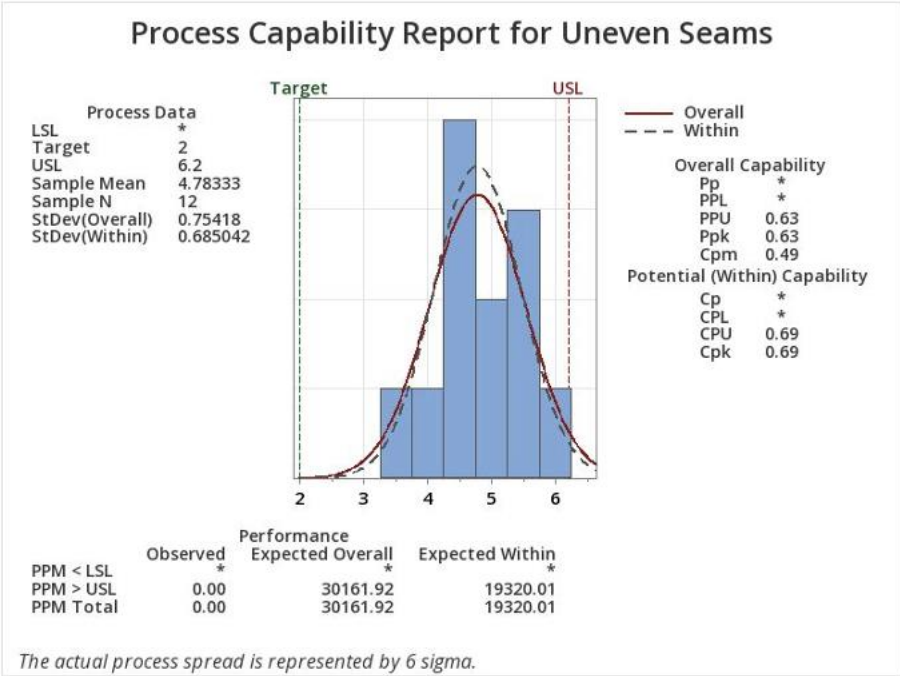


Current MOOI Sigma Level

Defects:	475
Units:	10.113
Opportunities per Unit:	1

DPMO:	46.969
Sigma Level:	3,17

Target MOOI Sigma Level

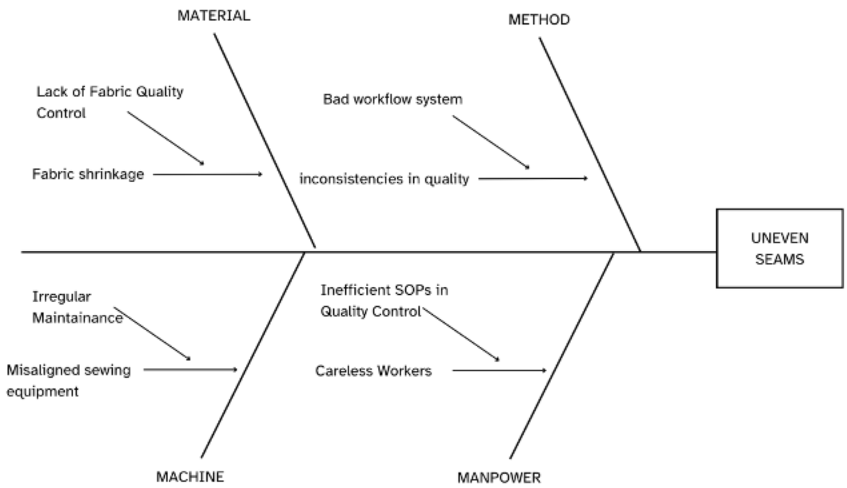
Defects:	202
Units:	10.113
Opportunities per Unit:	1

DPMO:	19.974
Sigma Level:	3,55

4.3 Analyze The "Analyze" phase identifies which defects should be prioritized for improvement. MOOI focuses on frequent defects, using a fishbone diagram to determine root causes, which include factors like human resources, materials, machinery, and methods. The analysis identifies the root causes of uneven seams, which were categorized by frequency and impact. High-frequency, high-impact causes are prioritized, with the workflow system and inefficient SOPs identified as key areas for improvement.

4.3.1 Root Cause Analysis The fishbone diagram, created in collaboration with MOOI's management, identifies bad workflow and inefficient SOPs as major causes of uneven seams. These root causes are prioritized based on their frequency and impact, which guides the focus for improvements in the next phase.

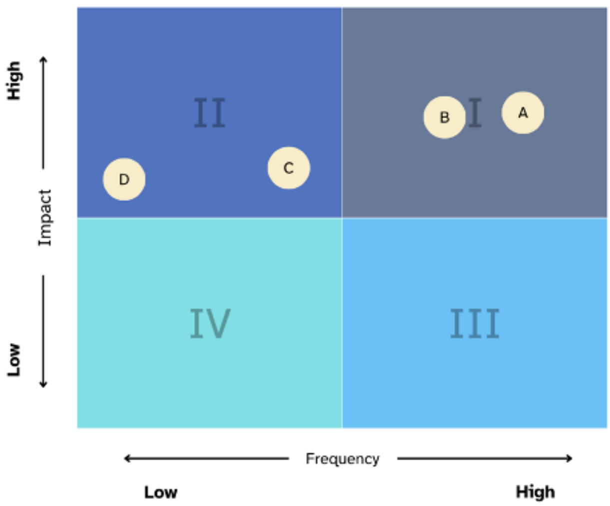
Fishbone Diagram



Root Cause

Defect	Factor	Root Cause	Letter
Uneven Seams	Method	Bad Workflow System	A
	Manpower	Inefficient SOPs	B
	Material	Lack of Fabric Quality Control	C
	Machine	Irregular Maintainance	D

Root Cause Classification



4.4 Improve

The "Improve" phase targets the prioritized root causes: bad workflow and inefficient quality control systems.

Fishbone Diagram for Uneven Seams

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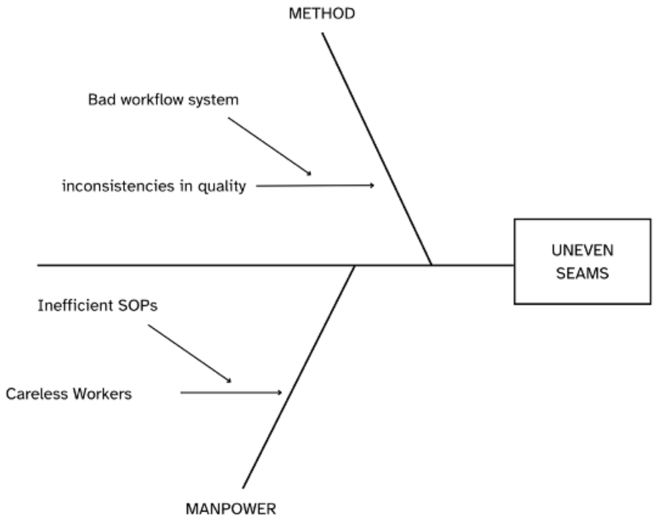
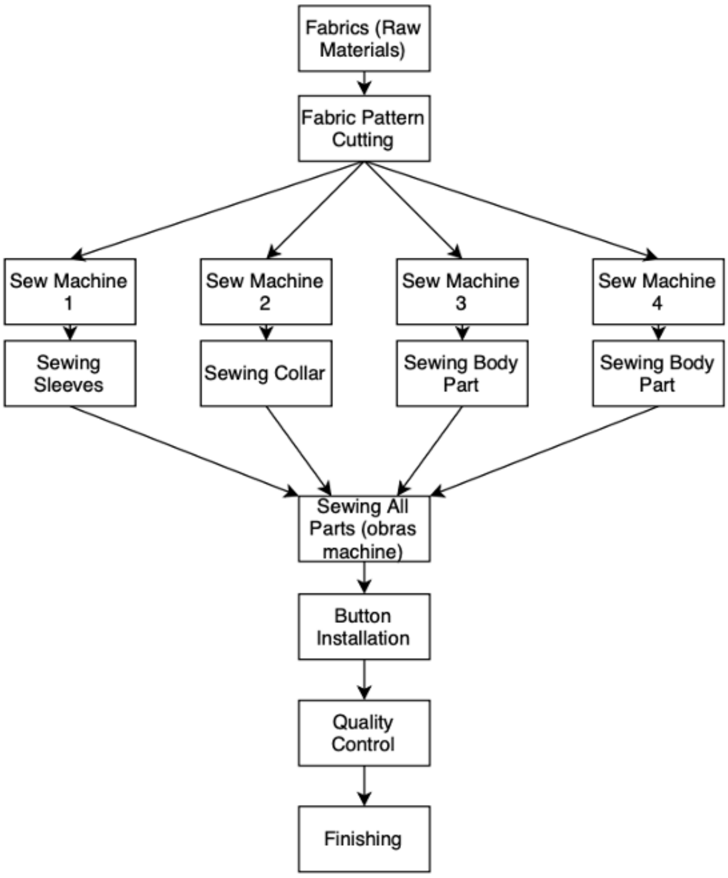


4.4.1 Alternative Solution For uneven seams, the proposed improvements include:

1. Method: A revised workflow system where each workstation focuses on a specific garment part. This approach enhances specialization and reduces defects. The new system splits tasks, such as assigning two stations to body parts, improving consistency and reducing defects from 6% to 2%. Intermediate quality control checks will be added to catch defects earlier.

Proposed Workflow

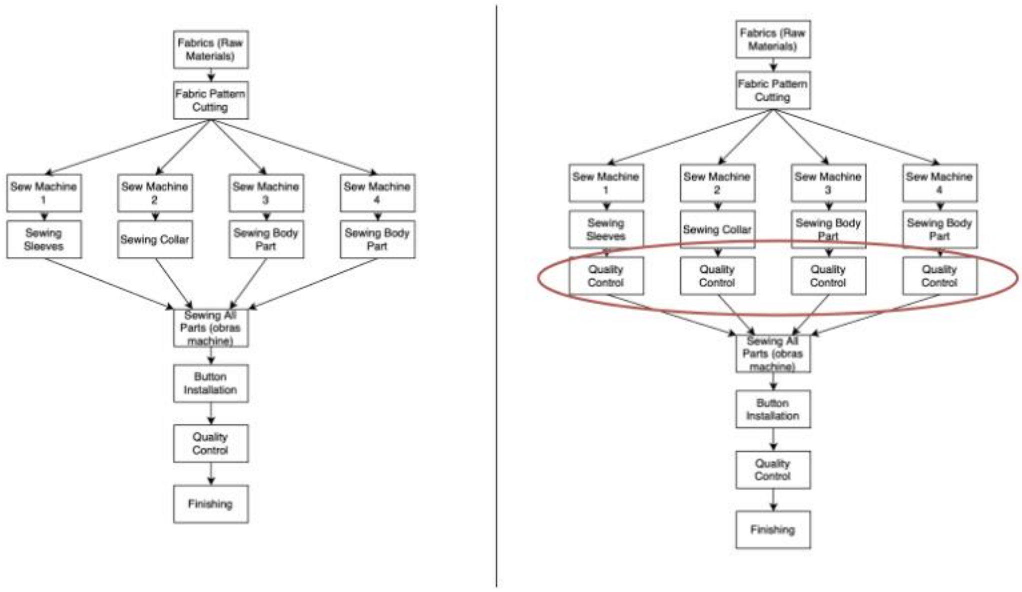


Proposed Improvement Output Calculation

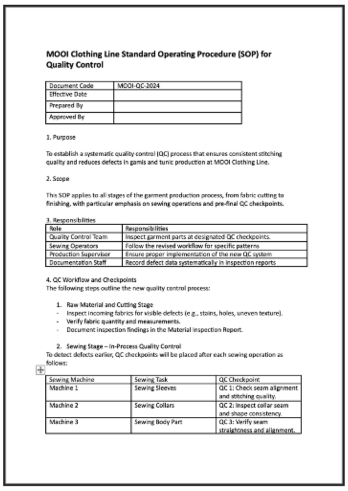
Workstation	Proposed Improvement	Expected Output (pieces)	Expected Impact
Workstation 1: Sewing Sleeves	Focus solely on sewing sleeves.	100 – 120 per day	Improved seam consistency, reduced defects from 6% into 2%
Workstation 2: Sewing Collar	Focus solely on sewing collars.	100 – 120 per day	Increased precision, reducing collar defects from 6% into 2%
Workstation 3: Sewing Body Part	Focus solely on body part sewing; assign 2 workers here.	50 – 60 per day	Balanced workload reduces delays, boosts output from 6% into 2%
Workstation 4: Sewing Body Part	Focus solely on body part sewing; allocate as per workload.	50 – 60 per day	Faster processing time, defect reduction from 6% into 2%
Quality Control	Introduce QC at each workstation stage.	Introduce QC at each workstation stage.	Early defect detection reduces rework from 6% into 2%

3. Manpower: MOOI's current end-stage quality control system will be enhanced by introducing intermediate checks before overlocking. This change will improve defect detection, reduce rework, and streamline the revision process. A new defect documentation system will also be implemented to improve monitoring and control.

Proposed Quality Control Step



Proposed Quality Control SOP



MOOI Clothing Line Standard Operating Procedure (SOP) for Quality Control

Document Code	MOOI-QC-2024
Effective Date	
Prepared By	
Approved By	

1. Purpose

To establish a systematic quality control (QC) process that ensures consistent stitching quality and reduces defects in gamis and tunic production at MOOI Clothing Line.

2. Scope

This SOP applies to all stages of the garment production process, from fabric cutting to finishing, with particular emphasis on sewing operations and pre-final QC checkpoints.

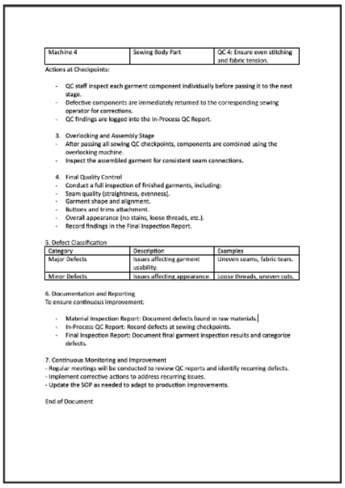
3. Responsibilities

Role	Responsibilities
Quality Control Team	Inspect garment parts at designated QC checkpoints.
Sewing Operators	Follow the revised workflow for specific patterns
Production Supervisor	Ensure proper implementation of the new QC system
Documentation Staff	Record defect data systematically in inspection reports

4. QC Workflow and Checkpoints
The following steps outline the new quality control process:

1. Raw Material and Cutting Stage
- Inspect incoming fabrics for visible defects (e.g., stains, holes, uneven texture).
- Verify fabric quantity and measurements.
- Document inspection findings in the Material Inspection Report.

2. Sewing Stage – In-Process Quality Control
To detect defects earlier, QC checkpoints will be placed after each sewing operation as follows:



Sewing Machine	Sewing Task	QC Checkpoint
Machine 1	Sewing Sleeves	QC 1: Check seam alignment and stitching quality.
Machine 2	Sewing Collars	QC 2: Inspect collar seam and shape consistency.
Machine 3	Sewing Body Part	QC 3: Verify seam straightness and alignment.
Machine 4	Sewing Body Part	QC 4: Ensure even stitching and fabric tension.

Actions at Checkpoints:

- QC staff inspect each garment component individually before passing it to the next stage.
- Defective components are immediately returned to the corresponding sewing operator for corrections.
- QC findings are logged into the In-Process QC Report.

3. Overlocking and Assembly Stage
- After passing all sewing QC checkpoints, components are combined using the overlocking machine.
- Inspect the assembled garment for consistent seam connections.

4. Final Quality Control
- Conduct a full inspection of finished garments, including:
- Seam quality (straightness, evenness).
- Garment shape and alignment.
- Buttons and trims attachment.
- Overall appearance (no stains, loose threads, etc.).
- Record findings in the Final Inspection Report.

5. Defect Classification

Category	Description	Examples
Major Defects	Issues affecting garment usability.	Uneven seams, fabric tears.
Minor Defects	Issues affecting appearance.	Loose threads, uneven cuts.

6. Documentation and Reporting
To ensure continuous improvement:

- Material Inspection Report: Document defects found in raw materials.
- In-Process QC Report: Record defects at sewing checkpoints.
- Final Inspection Report: Document final garment inspection results and categorize defects.

7. Continuous Monitoring and Improvement
- Regular meetings will be conducted to review QC reports and identify recurring defects.
- Implement corrective actions to address recurring issues.
- Update the SOP as needed to adapt to production improvements.

End of Document

4.5 Control

The "Control" phase defines control plans to ensure the sustainability of process improvements at MOOI.

1. Controlling Process Improvement: To evaluate the effectiveness of improvements, MOOI will assess process stability and capability. Statistical tools like control charts and DPMO calculations will be used to measure defects and track progress in achieving the company's quality goals.
2. Documenting the Implementation: Regular documentation of key parameters and measurements ensures ongoing monitoring of the improvements, helping to sustain quality and facilitate future adjustments.
3. Conducting Regular Team Meetings: Regular meetings will assess the effectiveness of corrective actions and set new objectives. These sessions also evaluate operator performance, identify challenges, and promote collaborative problem-solving to maintain production quality.
4. Continuing Continuous Improvement: After achieving initial goals, MOOI will set higher targets for continuous improvement. This ensures ongoing enhancement of production quality and supports the company's long-term operational excellence and market competitiveness.

5.1 Conclusion

The primary defects in MOOI's gamis and tunics production stem from uneven seams, fabric tearing, improper sizing, and missing buttons. These issues are caused by inconsistent sewing methods, poor maintenance, misaligned cutting patterns, and lack of focus or training among operators. Uneven seams, accounting for over 33% of defects, are the most critical concern.

Recommendations to Reduce Defects

1. Revise the Production Workflow: Segmenting the workflow by assigning specific tasks (e.g., collar, sleeve, or body parts) to each workstation will reduce seam inconsistencies and improve efficiency.
2. Implement Pre-Final Quality Control Checkpoints: Introducing quality control earlier in the process will help detect defects, like uneven seams, before reaching the final inspection, reducing costly rework.
3. Enhance Operator Training: Investing in structured training for operators on standardized sewing techniques and machine calibration will improve consistency and reduce defects.
4. Improve SOPs for Quality Control: Developing clear, standardized SOPs for quality control at each production stage will ensure defects are detected early and improve product quality.
5. Introduce Defect Documentation and Reporting: Implementing a defect tracking system will allow MOOI to monitor recurring issues, analyze corrective actions, and make data-driven improvements.
6. Use SPC and Process Capability Analysis: Incorporating Statistical Process Control (SPC) and process capability analysis will help monitor production stability and identify areas for improvement.
7. Foster a Continuous Improvement Culture: Encouraging regular team meetings to review performance and set higher quality targets will help MOOI maintain flexibility, efficiency, and long-term customer satisfaction.

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