Implementation of TQM Tools to Elevate Product Quality in RMG Industry: A Case Study

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Abstract

The garment industry of Bangladesh continues to experience rate of defects higher than international buyer requirements, where acceptable Defects per Hundred Units (DHU) typically range between 2–3%, particularly in sewing operations that lack robust quality management systems. This study aims to reduce sewing defects and improve Overall Equipment Effectiveness (OEE) through the well-structured implementation of Total Quality Management (TQM) tools. One of the sewing line producing short pants at Khan Fashion Limited was selected as a case study. Where Common defects named uneven stitch, broken stitch, skipped stitch, and puckering, were identified and systematically analyzed using basic tools of TQM named flowcharts, check sheets, histograms, control charts, scatter plots, Pareto analysis, and fishbone diagrams. These tools were applied to assess process capability, identify critical defect types, analyze the relationship between defect rates and production time, and determine root causes related to materials, methods, machinery, manpower, measurement, and environment. Based on the analytical findings and structured brainstorming sessions, appropriate corrective actions were introduced in the sewing line. The results found that the overall defect rate was reduced by 39.40%, achieving a final defect level of 3.26%, which aligns with international buyer requirements. Additionally, Overall Equipment Effectiveness (OEE) improved from 73.26% to 80.76% in that sewing line. Finally, it represents that application of TQM tools can significantly improve product quality and operational efficiency.

Keywords: *Total Quality Management (TQM), sewing defects, root cause analysis, Overall Equipment Effectiveness (OEE), garment manufacturing.*

1. Introduction

The Ready-Made Garments (RMG) is a vital industry of Bangladesh's economy, providing around 80% of the nation's export earnings. It has substantially driven economic development generating employment for many. In this RMG sector the sewing plays a vital role in production. The overall success of this industry depends on the fusion of skilled labor, modern equipment and technology. Serving users interest what we refer to as "Quality" has become vital. Quality has become a key element in the survival of companies in the competitive market (Thiagaragan et al., 2001). As human civilization progresses, quality will remain a defining marker of advancement (Ghazi Abu Taher et al., 2014). However, the RMG industry has consistently faced quality-related challenges, particularly in the sewing section, resulting in customer complaints, product rejections, and harm to its reputation. To

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rectify these issues, the RMG industries should emphasize on making the quality better by implementing robust quality control practices. Such steps will help to regain customer confidence, minimize return products and to re-establish the industry's global image.

Total Quality Management (TQM) address a comprehensive approach to enhancing product quality and customer satisfaction which emphasizes continuous improvement through the use of various tools and techniques. In the RMG context, the seven basic quality control tools are especially effective in boosting productivity and resolving problems related to quality and delivery throughout the production process (Memon et al., 2019). These tools help optimize efficiency and enable proactive problem-solving at every stage of production process.

The research will explore the process of implanting each tool, including data collection, analysis, and implementation. The implementation of these tools in the sewing department of the RMG sector can help firms to identify the root causes of quality-related problems and take corrective actions to prevent them, which can lead to enhanced product quality as well as customer satisfaction.

Objectives of the study

This study seeks to achieve the following objectives:

- To measure how the implementation of multiple tools of TQM in the RMG industry affects the reduction of sewing defects.
- To aim for a measurable decrease in defect rates.
- To increase Overall Equipment Effectiveness (OEE) through the effective use of TQM tools.
- To provide recommendations for implementing long-term quality improvement strategies in the RMG sector.

2. Literature Reviews

Globalization has made Bangladesh's garment industry widely recognized around the world. The RMG sector is a critical part of Bangladesh's economy, with more than 4 million workers employed in the industry. The garment industry in Bangladesh significantly contributes to the country's Gross Domestic Product (GDP), accounting for approximately 15% (Mottaleb & Sonobe, 2011). This industry in Bangladesh has attracted the attention of several large firms from industrialized and developed nations. Key reasons for investment include substantial foreign exchange earnings, cost effective workforce and favorable government policies. But this industry faces quality challenges. These include inadequate training during preproduction, inconsistent quality control during production, and poor finishing in post-production (Boateng et al., 2024).

Defects that are discovered after sewing and stitching have a detrimental impact on the costs of manufacturing (Kang et al., 2018). One key advantage of identifying a defect early is that it prevents the issue from affecting other processes or becoming more difficult and costly to fix later on (Fatima & Ahmed, 2005). Minor errors can lead to substantial economic losses and reputational damages, which can be addressed by quality management (Keist, 2015).

In today's global competitive market place the demands of customers are forever increasing as they require improved quality of products and services. The implementation of quality management tools has significantly contributed to the achievements of numerous industries and is widely adopted by companies on a global scale (Parveen et al., 2019). Total Quality Management (TQM) refers to a collection of techniques and procedures aimed at minimizing or eliminating variation in production processes or service delivery systems to enhance efficiency, reliability and quality (Steingard & Fitzgibbons, 1993). Total Quality Management is a comprehensive management philosophy focused on the continuous improvement of product and process quality to ensure customer satisfaction (Vuppalapati et al., 1995). Total Quality Management is a business strategy focused on delivering high-quality products with the goal of achieving customer satisfaction (Gul et al., 2012).

Total quality management, now a well-known idea, is a philosophy of management for continuously improving the quality of products and processes. According to (Mersha, 1997), Total Quality Management is a business approach designed to enhance an organization’s competitiveness by continuously improving the quality of its products, services, personnel, processes and work environments. The core idea of Total Quality Management is that ensuring the quality of products and processes is a shared responsibility among all individuals involved in their development and use. TQM engages management, employees, suppliers, and even customers to meet customer expectations. Common TQM practices include bringing together different departments to design products, managing processes carefully, working closely with suppliers to ensure quality, involving customers in decision-making and using feedback and data for continuous improvement (Aized, T., 2012).

3. Methodology

3.1 Implementing TQM

Total Quality Management is a management philosophy that emphasizes continuous improvement in all aspects of an organization's operations. The 7 basic tools of TQM are statistical techniques that can help organizations improve their processes and products. Here's a methodology for implementing these tools in a sewing line of a RMG industry (Figure 1).

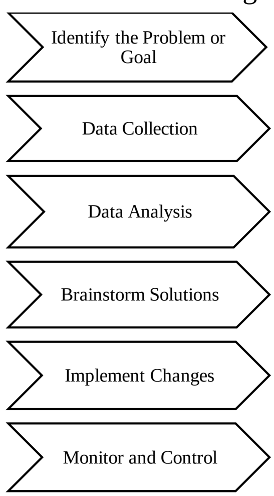


Figure 1 Methodology for implementing multiple Tools of TQM

3.1.1 Identify the Problem or Goal

Before implementing any of the tools, it's important to identify the problem or goal. In a sewing line of a garment, this could be anything from high defect rates to low productivity levels.

3.1.2 Data Collection

Once the area has been identified, data needs to be collected to better understand the problem. This could be done by observing the sewing process, reviewing defects report. Check sheets will be used to track the frequency of defects or issues in the sewing process.

3.1.3 Analyze the Data

The next step is data processing, at this stage the tools are used in a few sequences. For example-

-The first is to create a control chart to study how the process changes over time. A p- chart also known as a proportion chart, is one of the control charts used in statistical process control to monitor the proportion of defective items or non-conforming units in a sample over time. A control chart always has a central line for the average, an upper line for the upper control limit, and a lower line for the lower control limit.

- The second is to create a scatter diagram to see the positive and negative relationship between two variables: the production time and the defective rate (%).

- The third is to identify the highest type of disability through the histogram. It displays the distribution of the values in a data series. By using a histogram, we can see accurate data trends, compare groups of data, and identify outliers. These features can help us in identifying and quantifying quality issues in the sewing process.

- The fourth is to create Pareto diagram is used to identify the key defects or issues in the sewing process. If the problems are eliminated then 80% of the defects will be reduced.

3.1.4 Brainstorm Solutions

After finding the key defects or issues in the sewing process, cause-and-effect diagram will be used to identify the root causes of the problem in the sewing process. It forces us to think about all the potential causes and provide solutions to improvement or change in the object studied.

3.1.5 Implement Changes

Based on the analysis of the data using the 7 basic tools, put selected solutions into action in the sewing process. This could involve process improvement, modifying equipment, or other corrective actions.

3.1.6 Monitor and Control

Finally, continuously monitor the process or system to ensure that the changes made are effective in reducing defects or achieving the quality goal. Control charts can be helpful in this phase. If necessary, adjustments can be made for further improvements.

From the research conducted, it is effective to use seven basic tools for implementing and analyzing quality control system. These tools combined would be a beneficial for research conducted in quality system.

3.2 Data Collection

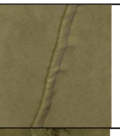
The Table 1 showing the defective product data of short pants during 6th September 2023 to 11th September 2023 on a sewing line in Khan Fashion Ltd.

Table 1 Check sheet for defects

Defect Types	Weekdays					Total
	Wednesday	Thursday	Saturday	Sunday	Monday	
Broken Stitch	卌|	卌卌|	卌||	卌卌	卌|	40
Skip Stitch	||||	卌|	卌	卌	|||	23
Open Seam	||	|	0	||	0	5
Bad Tension	|||	|||	|||	|||	卌||	19
Un-Even Shape / Stitch	卌||||	卌卌|	卌卌	卌	卌卌||	47
Raw-edge / Raw-edge out	||	0	||||	|||	|||	12
Over Stitch	||	|||	|	|||	|||	12
Down Stitch	卌	||||	||||	卌	||||	22
Puckering	||	|||	||	||	卌	17
Pleat	|||	卌||||	卌||	卌	卌卌	34
Single Stitch	卌|	卌||	卌	卌|||	卌|	32
Sharing	0	0	||||	0	0	4
Uncut Thread	0	||	0	0	0	2
Up Down	卌|||	卌|||	卌卌||	卌	卌||	40
Others	0	0	0	0	0	0
Total	69	69	67	55	66	309

The following Table 2 illustrating the real images corresponding to the data on known types of defects which are often found in short pants in the company.

Table 2 Types of defects.

Type of defects	Reference Image
i. **Broken Stitch:** Broken stitch is a sewing defect where the thread breaks or doesn't hold properly, leading to a weak or unreliable seam in a product.	
ii. **Skip Stitch:** Skip stitch occurs when the sewing machine misses one or more stitches in a continuous line. This results in a gap in the seam, compromising the overall integrity of the stitch.	
iii. **Open Seam:** An open stitch is a sewing defect where the stitches are not tightly interlock, leaving gaps between them. This can lead to a weak seam that is prone to unraveling.	
iv. **Bad Tension:** Bad tension refers to uneven tightness of the stitches in a seam. It can cause the fabric to pucker or the stitches to be too loose, compromising the overall quality and appearance of the sewing.	
v. **Uneven Shape/Stitch:** Un-even shape/stitch refers to the stitching or sewing on a product that isn't consistent, causing it to look irregular or misshapen.	
vi. **Over Stitch:** Over stitching happens when the machine makes more stitches than necessary in a particular area. This can result in a bulky and uneven seam, affecting the overall look and feel of the product.	
vii. **Puckering:** Puckering is the undesirable gathering or wrinkling of fabric along a seam. It is often caused by improper tension or stitching techniques and can detract from the smoothness of the final product.	
viii. **Uncut Thread:** Uncut thread occurs when the thread is not trimmed properly after sewing. This can lead to loose threads hanging from the seam, affecting the neatness and overall quality of the product.	
ix. **Up-Down:** Up-down defects typically refer to irregularities in the hemline of a garment, causing to appear uneven or misaligned.	

The graph (Figure 2) showing the amount of production units and the number of defective products in short pant starting from day 1 to day 5.

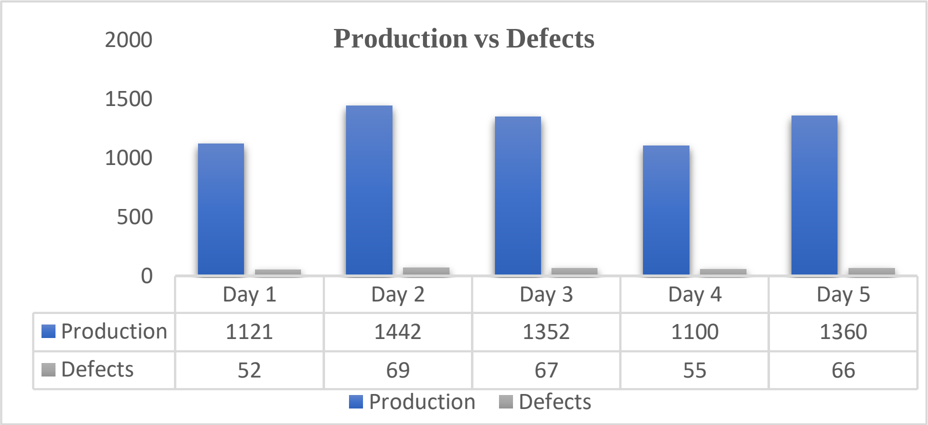


Figure 2 Production unit and number of defects

3.3 p-Chart analysis

Here,

Defective Rate, $p = \frac{Number\ of\ defects}{Sample\ Size} = \frac{d_i}{n}$

Average Defective Rate, $\bar{p} = p \div k = 0.048$

No. of lots, $k = 10$

Control limit for p chart:

$$UCL_p = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$LCL_p = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

The *P*-chart analysis in this study confirmed that defects within the process were under control line, indicating process stability and adherence to quality standards (Figure 3). However, the study focused towards pursuing process optimization and enhancing quality further. The objective was not only to maintain control but also to reduce defects and elevate product quality to even higher levels.

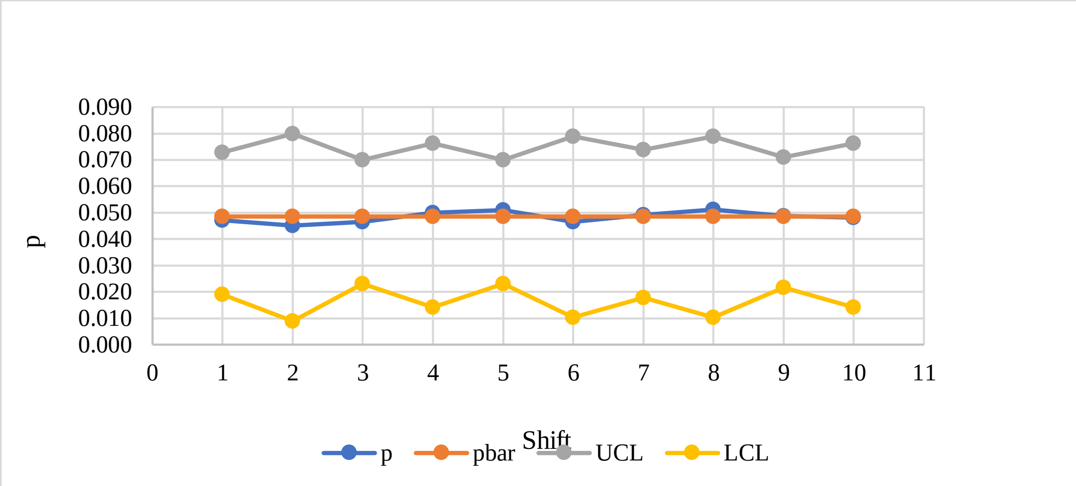


Figure 3 p-Chart analysis

3.4 Histogram

A histogram is a graphical tool used to display the frequency of each defect type within a dataset, illustrating the distribution of various sewing defects identified. Figure 4 shows the frequency of the different types of defects for the collected dataset.

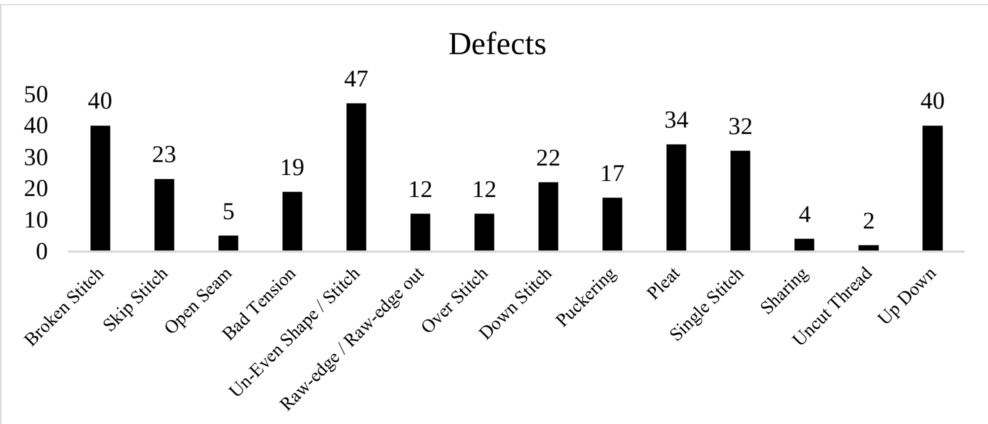


Figure 4 Histogram for the defects

3.5 Scatter Diagram Analysis

A scatter diagram illustrating defect rate percentages against production time provides a visual means to analyze the relationship between defect occurrences and the progression of time. Table 3 presenting the defect rate percentage within the observation time and the corresponding scatter diagram Figure 5 showed that the defective rate (%) exhibited higher frequencies during specific time intervals. Notably, defective rates were higher during the initial hour of the shift and the last hour of the shift. This observed temporal variation raises questions about potential contributing factors, such as operator fatigue, process adjustments during shift transitions, or other dynamic elements within the production environment. Findings and addressing these time-related differences is essential for maintaining consistent quality during production.

Table 3 Defective rate percentage over time

Production Time	Defective Rate (%)
08-09 AM	4.634
09-10 AM	4.178
10-11 AM	4.17
11-12 PM	4.136
12-01 PM	4.102
01-02 PM	Lunch Time
02-03 PM	4.194
03-04 PM	4.17
04-05 PM	4.344

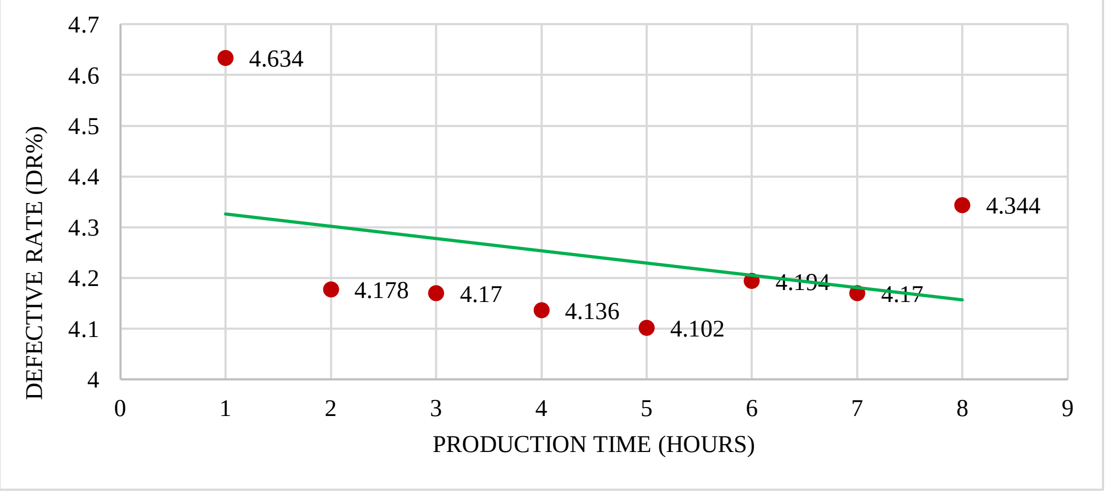


Figure 5 Scatter diagram for defective rate percentage and time

3.6 Pareto Analysis

Pareto analysis is a method used to identify and prioritize the most critical factors or issues contributing to a problem or outcome. It helps focus resources on addressing the most significant issues to achieve the greatest impact. It guides efficient resource allocation and problem-solving by focusing on the vital few over the trivial many. Table 5 shows the

Table 5 Top defects with cumulative percentage

Defects	Quantity	Cumulative Total	Cumulative (%)
Un-Even Shape/Stitch	47	47	15%
Broken Stitch	40	87	28%
Up Down	40	127	41%
Pleat	34	161	52%
Single Stitch	32	193	62%
Skip Stitch	23	216	70%
Down Stitch	22	238	77%
Bad Tension	19	257	83%
Puckering	17	274	89%
Raw-edge/Raw-edge out	12	286	93%
Over Stitch	12	298	96%
Open Seam	5	303	98%
Sharing	4	307	99%
Uncut Threads	2	309	100%
Total	**309**		

3.6.1 Pareto Analysis Observations

From the table, we can clearly observe:

i. Most common defect was 'Un-even shape/stitch,' accounting for 15% of the total.
ii. Following closely, 'Broken stitch' and 'Up-down' each make up 13% of the total defects, securing the second position.
iii. These top three defects, 'Un-even shape/stitch,' 'Broken stitch,' and 'Up-down,' collectively known as the 'vital few,' dominate the defect distribution.

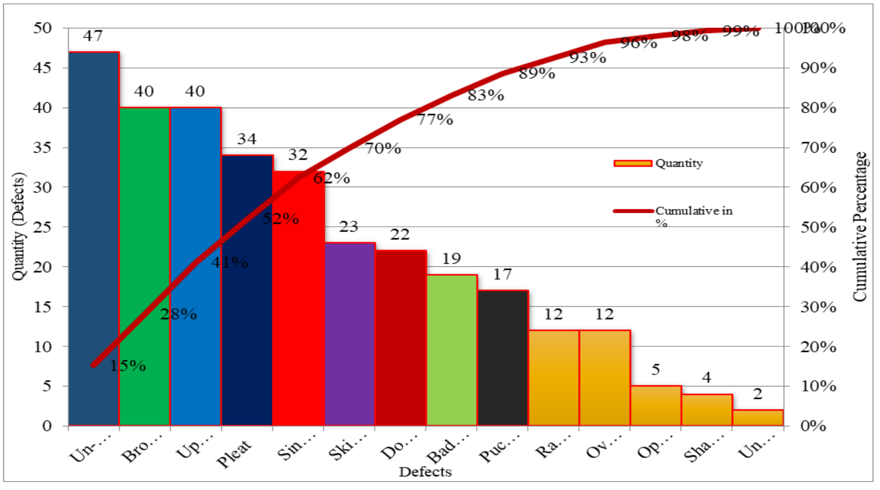


Figure 6 Pareto chart for sewing defects

3.7 Cause and Effect Analysis

Cause and effect analysis, represented as a fishbone diagram, is a visual tool used to systematically explore and understand the underlying causes of a problem. It helps teams identify multiple potential factors contributing to an issue and facilitates problem-solving and decision-making.

3.7.1 Cause and effect analysis for un-even shape/stitch

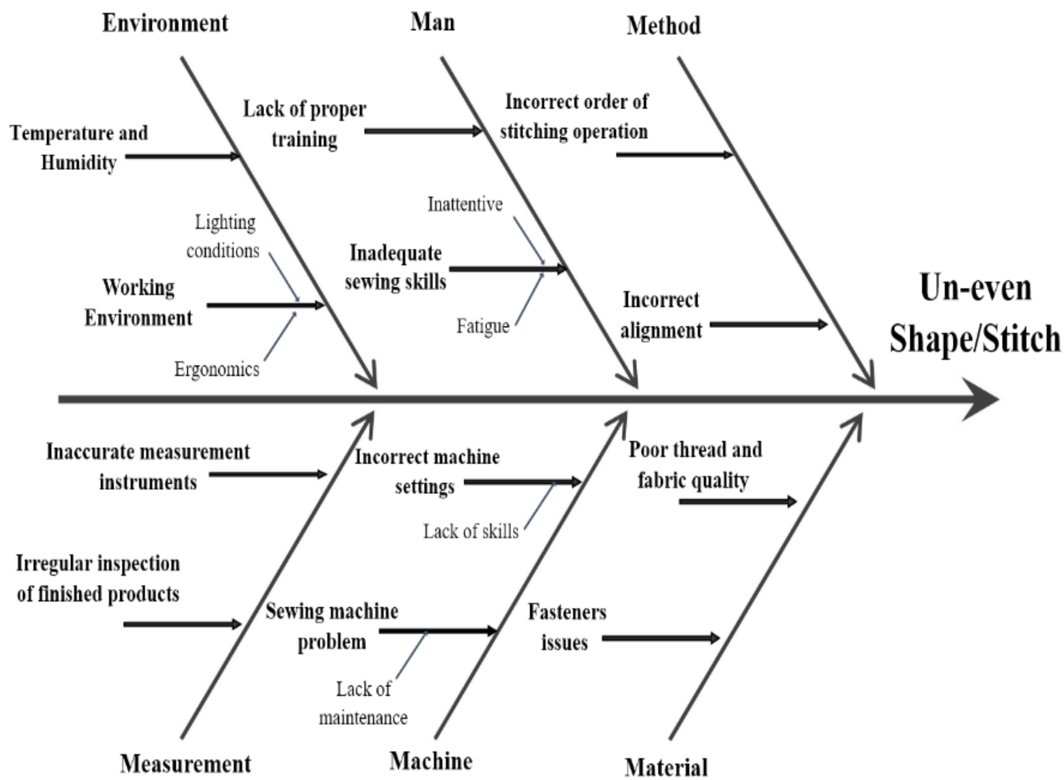


Figure 7 Cause and Effect diagram for un-even shape/stitch

Corrective actions for un-even shape/stitch

- The machine operators were instructed not to pull the fabric while sewing, allowing the machine to handle it properly.
- They ensured the right needle, correct feed control, and accurate machine settings were used for production.
- The machine technician ensured that the machine settings were accurate before production.

3.7.2 Cause and effect analysis for broken stitch

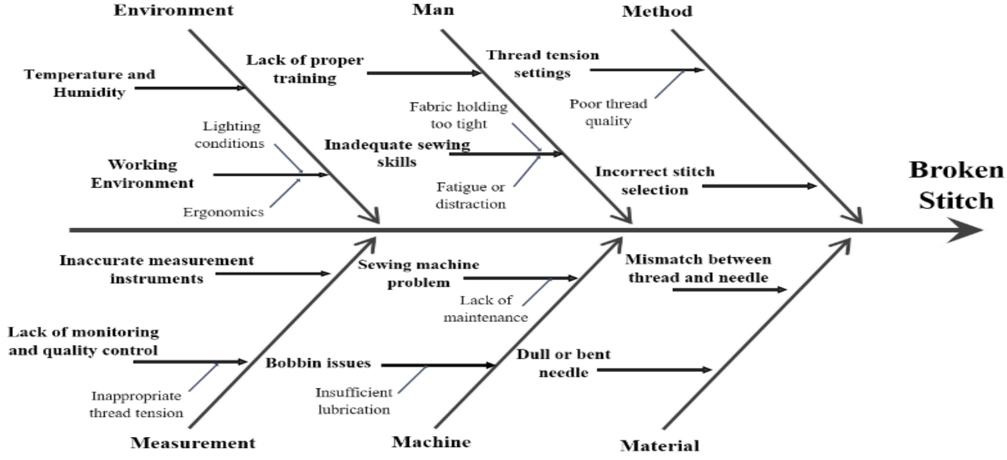


Figure 8 Cause and Effect diagram for broken stitch

Corrective actions for broken stitch

- The thread tension was properly adjusted by the operators for the specific fabric and sewing task.
- It was ensured that the needle size and thread size were compatible and suitable for the material being sewn.
- Regular inspections were carried out, and dull or bent needles were replaced to prevent issues like broken stitches.

3.7.3 Cause and effect analysis for up-down

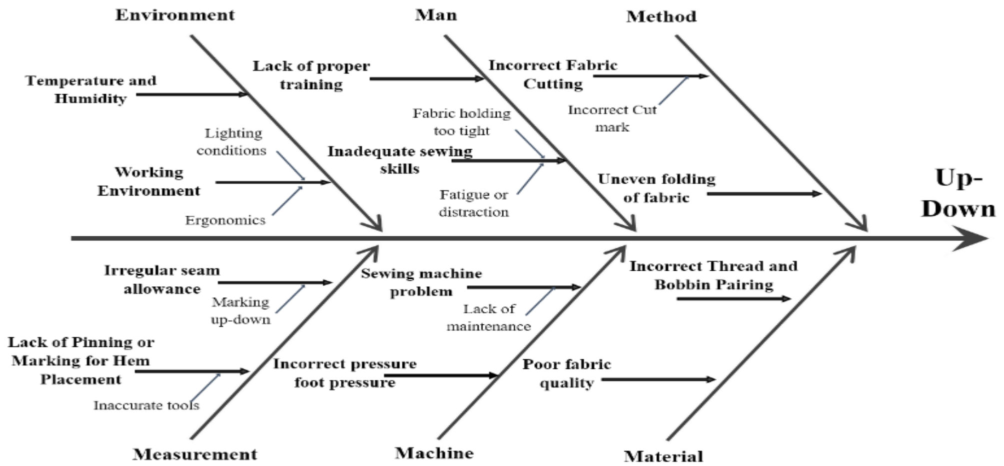


Figure 9. Cause and Effect diagram for up-down stitch

Corrective actions for parts up-down

- Pattern makers ensured that the cut marks for the bottom hem were accurately placed to guide sewing operators effectively.
- Engaged in a discussion with the line supervisor to provide work instructions that clearly defined the correct seam alignment and stitching process for the bottom hem.

4. Results and Discussion

After implementing the seven basic tools of Total Quality Management (TQM) in the sewing line and taking corrective actions to address defects, a significant reduction in sewing defects was observed. This shows the effectiveness of the TQM initiatives in enhancing the overall quality of the sewing processes.

Table 6 Number of defects before and after implementation

Defects	Before Implementation Defects	After Implementation Defects
Un-Even Shape/Stitch	9.4	6
Broken Stitch	8	5
Up Down	8	6
Pleat	6.8	5
Single Stitch	6.4	5
Skip Stitch	4.6	4
Down Stitch	4.4	3
Bad Tension	3.8	2
Puckering	3.4	3
Raw-edge/Raw-edge out	2.4	2
Over Stitch	2.4	1
Open Seam	1	2
Sharing	0.8	0
Uncut Threads	0.4	0
Total	60	44
Length Produced	1115	1207
Defects (%)	**5.38**	**3.26**

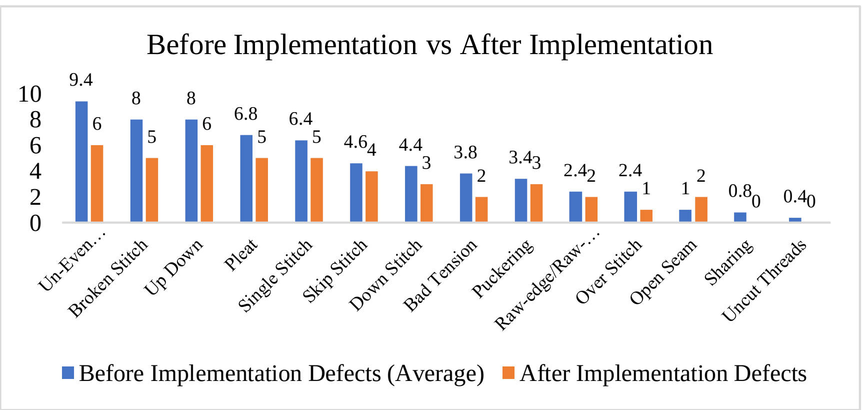


Figure 10 Defects found before implementation and after implementation

After taking corrective actions, sewing defects were decreased to 3.26% from 5.38%, improving product quality.

4.1 Overall Equipment Effectiveness (OEE)

OEE stands for Overall Equipment Effectiveness, and is generally considered to refer to a measurement in "Total Productive Maintenance" programs. The measure looks at effectiveness and efficiency of machinery or processes and is commonly referred to in reference to Lean Manufacturing.

The formula used to calculate OEE is as follows: *OEE = Availability x Performance x Quality*

Table 7 Overall Equipment Effectiveness (OEE) before implementation

% Availability	(Loading time - Down time) ÷ Loading time
	(480-60) ÷ 480 = 0.875
	87.5%
% Performance	$= \frac{Quantity\ produced}{Time\ run \times \frac{Capacity}{Given\ Time}} \times 100$
	$= \frac{1115}{420 \times 3} \times 100 = 0.8849$
	88.49%
% Quality	(Amount produced - Amount waste) ÷ Amount produced
	(1115-60) ÷ 1115 = 0.9462
	94.62%
Overall Effectiveness	Availability × Performance × Quality
	0.7326
	73.26%

Table 8 Overall Equipment Effectiveness (OEE) after implementation

% Availability	(Loading time - Down time) ÷ Loading time
	(480-60) ÷ 480 = 0.875
	87.5%
% Performance	$= \frac{Quantity\ produced}{Time\ run \times \frac{Capacity}{Given\ Time}} \times 100$
	=1207 ÷ (420 × 3) = 0.9579
	95.79%
% Quality	(Amount produced - Amount waste) ÷ Amount produced
	(1207-44) ÷ 1207 = 0.9635
	96.35%
Overall Effectiveness	Availability × Performance × Quality
	0.8076
	80.76%

The study showed that the Overall Equipment Effectiveness (OEE) was increased from 73.26% to 80.76% by implementing the seven basic tools of Total Quality Management

(TQM). This improvement was realized through a comprehensive approach that involved defect reduction and a substantial increase in short pants production. This accomplishment underscores the effectiveness of TQM tools in optimizing manufacturing efficiency.

5. Conclusion

The study explored the implementation of Total Quality Management (TQM) principles, specifically focusing on the use of the seven basic tools, within Bangladesh's Ready-Made Garments (RMG) industry. The primary objective was to reduce sewing defects in the production of short pants, with a dual aim of enhancing overall product quality and operational efficiency. Through a comprehensive analysis of the seven basic tools of TQM, the study demonstrated their pivotal role in identifying and rectifying sewing defects, resulting in a reduction of defect percentages from 5.38% to 3.26%. The implementation of these tools has positively impacted the defect rates, contributing to the overall improvement in product quality. Furthermore, this study unveiled the crucial impact on Overall Equipment Effectiveness (OEE), a key performance metric. The reduction in defect rates not only improved product quality but also elevated OEE from 73.26% to 80.76%, reflecting an enhancement in equipment and process efficiency. In conclusion, the study marks the conclusion of academic exploration and the initiation of a transformative path for quality management in Bangladesh's RMG industry. The integration of defect rate improvement into the findings underscores the comprehensive impact of TQM principles, inspiring positive change and guiding RMG factories toward a future where both product quality and operational efficiency are crucial.

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