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# Defect Reduction and Efficiency Enhancement in a Knit Garment Factory using Lean Six Sigma DMAIC Methodology

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## Abstract

This study successfully applied the Lean Six Sigma DMAIC methodology to tackle quality and efficiency issues in a knit garment factory. Focusing on a polo shirt production line, we used the structured DMAIC (Define-Measure-Analyze-Improve-Control) approach to identify and solve key problems. Our investigation began with a Pareto analysis, which pinpointed the seven most critical sewing defects. We then used Fishbone diagrams to dig deeper, uncovering root causes like blunt needles and insufficient operator training. In response, we implemented targeted Kaizen, such as retraining operators and standardizing machine maintenance, guided by the PDCA cycle. The outcome of these efforts was a clear and positive improvement. Most notably, the defect rate fell substantially from 24.26% to 15.54%. At the same time, daily production rose from 796 to 863 pieces, and line efficiency improved from 36.89% to 40.00%. Finally, statistical tests confirmed that our improvements were real and not random. This work provides a validated, practical model for enhancing quality and efficiency enhancements in knitwear manufacturing.

## Keywords
line efficiency, sewing & finishing defects, pareto analysis, root cause analysis, polo shirt

## 1. Introduction
Garment industries commonly face the challenges of high defect rates and lower efficiency in developing countries. For instance, the average efficiency in garment industries of Bangladesh were 40%-45% in 2024, **(Nayeem and Sayeda 2024)**. Since this sector has become competitive now-a-day, industries should concentrate on defect reduction and efficiency improvement to sustain in this business.

Our study focuses on quality improvement and production efficiency in ready-made garments. Production defects are a common challenge that significantly impact overall performance. This research seeks to identify the main areas for improvement so we can achieve better results. Enhancing these factors is significant to growing up in the competitive market. Therefore, our primary goal is to improve quality and increase efficiency.

This work will be conducted using process improvement methods. This approach is based on the main principles of continuous improvement. We will apply quality management tools to analyze the production workflow. This strategy will ensure that our changes are effective as well as meaningful. The overall target is to implement a structured framework for upgrading current operations.

We concentrate especially on the ready-made garments industry in developing countries. The research was performed in a clothing factory that deals with the typical challenges, which are the common issues in the local garment production sector. This environment offered us a practical field to explore different ways to improve quality and efficiency. The result of this work is applicable to similar manufacturing environments. Thus, the outcomes of this project aim to help the country's larger textile industry.

### 1.1. Research gap and contribution

Most previous studies rely on single methods like Kaizen and lack statistical validation. Furthermore, there is a significant gap in research that combines the complete Lean Six Sigma DMAIC approach to complex knitwear like a polo shirt. To address this, our work implements the full DMAIC methodology for polo shirt production and uses hypothesis testing to statistically prove defect and efficiency improvements, offering a validated model for the industry**.**

### 1.2. Research Question

How does the Lean Six Sigma DMAIC methodology improve quality and efficiency in the sewing and finishing section of a knit garment factory?

### 1.3. Research Hypothesis

The post-Kaizen period will show us a significant reduction in defects and improvement in efficiency compared to the pre-Kaizen period.

### 1.4. Research Objectives

1. To identify the major sewing and finishing defects in the polo shirt production line.
2. To reduce defect rate and improve efficiency.

## 2. Literature Review

In this section, we will indicate some existing research articles on quality and productivity improvements in different industries. Our focus is on specific methodologies like root cause analysis, PDCA (Plan-Do-Check-Act), and Six Sigma DMAIC Methodology to find how well they work when dealing with production problems.

A root cause analysis is a significant tool for identifying the reasons for critical defects in manufacturing industries. Several apparel industry studies confirm the method's effectiveness. Kapuria et al. (2017) used root cause analysis to reduce defects in a garment factory and showed the line efficiency increased from 45% to 60%. Chowdhury and Rahi (2021) also used the same tools in a T-shirt sewing section, where they found that eight main faults caused 79% of all production problems. This approach of separating the "vital few" defects from the "trivial many" is crucial for targeting our improvement area. Applications of root cause analysis are not limited to the apparel sector; as shown by Roy et al. (2021), production line defects were reduced by 56.66% in an automobile factory in Bangladesh using some of root cause analysis's tools, like the check sheet, histogram, Pareto diagram, and cause and effect diagram. Therefore, root cause analysis is a proven methodology that effectively identifies and addresses the primary causes of defects on the production floor.

In various industries, both Kaizen and the PDCA cycle are used as continuous improvement tools. Kaizen specifically focuses on small and incremental changes implemented for all employees, where the PDCA cycle provides a systematic, four-step framework for implementing and standardizing improvements. A global review by **George et** al. (2022) confirmed that Kaizen applications in various countries help maintain ergonomic standards and resolve fabric faults. Nada and Alansour (2024) found that Gemba Kaizen, a method focused on improving production quality, effectively reduced process waste in Egypt's textile industry. The PDCA cycle provides a systematic framework for implementing improvements. In Indonesia, Kurnia et al. (2022) used the PDCA cycle and Overall Equipment Effectiveness (OEE) to boost production output by 112%. In a men's formal jacket factory, Sjarifudin and Gift (2022) showed a 33.7% monthly reduction which was achieved by integrating PDCA with seven quality tools in major defects. It is evident that Kaizen and PDCA are very effective methods for achieving continuous improvements in quality and productivity.

More organized and data-driven approaches such as Total Quality Management (TQM), Lean, and Six Sigma are used to achieve major improvements. TQM involves quality control throughout the entire company. This is illustrated by Joy et al. (2024), who used a TQM approach with Pareto and Histogram in a sewing line to improve output, minimize Standard Allowable Minute (SAM), save manpower, and reduce costs. On the other hand, Lean manufacturing focuses on waste elimination. For example, Lingkon et al. (2024) applied various Lean tools like PDCA and 5S in a Bangladeshi T-shirt factory to reduce the defect rate from 5.5% to 3% and increase the quality rate from 94% to 98%. The most valuable of these approaches is Six Sigma, which reduces variation and faults by applying the DMAIC methodology. For instance, Hieu and Anh Van (2025) applied DMAIC in a Vietnamese denim company to reduce monthly defective fabric products from 6050 to 3046 meters. Moreover, Kurnia et al. (2021) used DMAIC to cut defect rates from 11.08% to 5.54% in a knitting socks industry in Indonesia, and Meresa et al. (2025) achieved a reduction from 4.73% to 0.61% in a bag production finishing section in Ethiopia. These findings proved that the DMAIC framework is highly effective for quality improvement methodology in the textile sector.

Based on the reviewed articles, quality tools like RCA, Kaizen, PDCA, and the structured DMAIC methodology are well-suited for solving garment production problems. Studies by Kapuria et al. (2017) and Chowdhury and Rahi (2021) proved these tools reduce defects in sewing sections. The PDCA cycle has also been shown to improve efficiency, as shown by Kurnia et al. (2022). Furthermore, the DMAIC methodology of Lean Six Sigma has been highly effective in textile production, as demonstrated by Hieu and Anh Van (2025).

However, it is evident that a clear gap still exists in the combined application of these approaches. There is a lack of research that integrates the full Lean Six Sigma DMAIC framework specifically within a knit garment factory for a complex product like a polo shirt. More importantly, no study uses statistical hypothesis testing to validate if the improvements are significant or random. Therefore, our goal is to use Lean Six Sigma's DMAIC methodology to reduce defects and increase efficiency in polo shirt production. Additionally, the application of hypothesis testing will ensure the accurate statistical validation of the improvements, which will be a dedicated model for knit garment improvement.

## 3. Methods

This study applied the Lean Six Sigma DMAIC methodology to minimize sewing and finishing defects in polo shirt production at Esquire Knit & Composite PLC. Our project was structured in two phases: a three-month pre-Kaizen baseline period (October–December 2024) and a one-month improvement and evaluation phase (January 2025).

### 3.1. Define Phase

In this phase, we established the project foundation by defining the problem, setting the scope, and aligning with organizational goals. The core issue was a high defect rate and low efficiency in a specific polo shirt style. To ensure a focused investigation, the project was scoped to Line-10 in Unit-6, which was a dedicated polo shirt line. This initiative directly supported the organizational objective to increase productivity by significantly reducing the defect rate.

### 3.2. Measure Phase

This phase focused on establishing the baseline performance metrics. The key metrics calculated were Defect Rate (%) and Line Efficiency (%), using Equations 1 and 2. The specific sources and methods for gathering the production data used in these calculations are detailed in the following section.

Key performance metrics were calculated using the following equations:

$$\text{Defect Rate (\%)} = \frac{\text{Total Defects}}{\text{Total Inspected Garments}} \times 100 \tag{1}$$

$$\text{Line Efficiency (\%)} = \frac{Daily\ Output \times SMV}{Number\ of\ Manpower \times Available\ Minutes} \times 100 \tag{2}$$

Daily output, defined as the total number of polo shirts produced per day and it was the foundational unit for these calculations.

### 3.3. Analyze Phase
In this phase, we used data analysis tools to identify the root causes of the major defects.

- **Pareto Analysis:** A Pareto chart was constructed to identify the "vital few" defects that were responsible for approximately 80% of the total problems. The top defects identified were broken stitch, open seam, skip stitch, and uncut thread.
- **Root Cause Analysis:** For each of the top defects, a Fishbone Diagram was developed using the 6M framework (Man, Machine, Method, Material, Measurement, Mother Nature) to systematically identify the main root causes.

### 3.4. Improve Phase
Based on the root cause analysis, our targeted corrective actions were developed and implemented using kaizen. In the kaizen implementation segment, we executed improvements using the PDCA (Plan-Do-Check-Act) cycle. Where key actions were included:

- **Man:** Retraining operators on standard work procedures and quality awareness.
- **Machine:** Implementing daily needle changes and regular maintenance of trimmers and presser feet.
- **Method:** Revising for Standard Operating Procedures (SOPs) and improving workstation layouts.
- **Material:** Collaborating with the fabric and thread sourcing department for quality consistency.

### 3.5. Control Phase
The objective of this phase was to sustain the improvements.

- **Standardization:** Updated SOPs and work instructions were documented and communicated to all shift operators and line supervisors.
- **Monitoring:** The IE team continued to monitor the key performance indicators is defect rate, efficiency in daily basis.
- **Statistical Validation:** A hypothesis test was conducted to statistically validate that the observed improvements were significant and not due to random chance.

### 3.6. Data Analysis Tools
We used Microsoft Excel as the primary tools for data analysis, compiling data, creating Pareto charts, and performing basic statistical calculations. The hypothesis testing was also conducted using standard statistical formulas within this framework.

## 4. Data Collection
We used both primary and secondary data. Data was gathered from the polo shirt production line (Line-10, Unit-6) at Esquire Knit & Composite PLC over a four-month period, covering both the pre-Kaizen (October-December 2024) and post-Kaizen (January 2025) phases.

- Primary data included daily production reports, defect records, and efficiency logs, manually documented by the industrial engineering team in collaboration with line supervisors and quality control personnel.
- Secondary data was sourced from internal documentation like Standard Minute Value (SMV) specifications and historical quality audit reports.

We calculated the two key performance metrics daily: the Defect Rate using Equation 1 and the Line Efficiency using Equation 2 from the Methodology section.

## 5. Case study in a Knit Garment
This section presents an analysis of collected data from before and after implementation of kaizen to examine its impact on defect reduction, productivity enhancement, and operator performance.

### 5.1. Defect Analysis
To establish a performance baseline, Table 1 summarizes the average monthly defect counts for the major defect categories observed during the pre-kaizen period (October to December 2024)

Table 1. Summary of Sewing and Finishing Defects (October–December 2024)

| **Defect Area** | **Average Monthly Defects (pcs)** | **Description** |
|---|---|---|
| Sewing | 5,931 | Includes uncut thread, broken stitch, skip stitch, open seam, and other sewing defects. |
| Finishing | 735 | Includes dirty spot, stain, pressing defects, and other finishing defects. |

The baseline data reveals that sewing defects account for the majority (89%) of total quality issues, confirming this area as the most critical section and our primary focus for improvement.

## 5.2. Pareto Analysis

To further pinpoint the specific problems within the sewing section, the 80/20 rule was applied through a Pareto analysis. This chart identified the top recurring defects that were responsible for approximately 80% of total sewing rejections. Figure 1 visualizes the distribution of the top defects recorded during the three-month pre-kaizen periods:

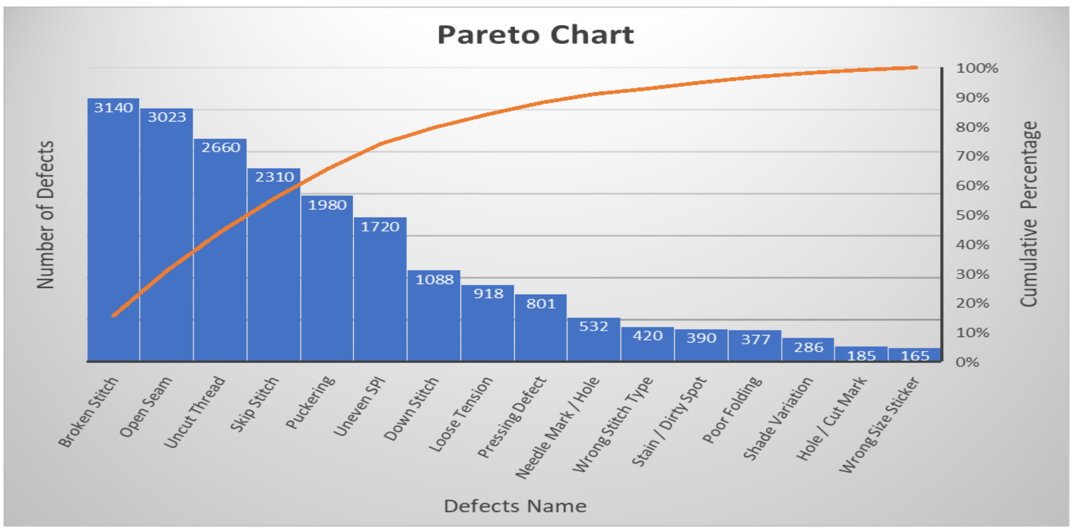


Figure 1. Pareto Chart of Sewing and Finishing Defects (October to December 2024**)**

The Pareto analysis revealed seven critical defects are broken stitches, open seams, uncut thread, skipped stitches, puckering, uneven SPI (stitches per inch), and down stitch. This finding confirmed that we should concentrate our improvement efforts on the sewing section.

## 5.3. Root Cause Analysis

A root cause analysis was conducted to identify the underlying reasons behind the seven major defects observed in the processes of polo shirts. The analysis followed the 6M (Man, Machine, Method, Material, Measurement, and Mother Nature) framework. To visualize this process, fishbone diagrams were developed for each defect, highlighting possible contributing factors of defects. These visuals are presented in Figure. 2 to Figure. 9, corresponding to top seven defects

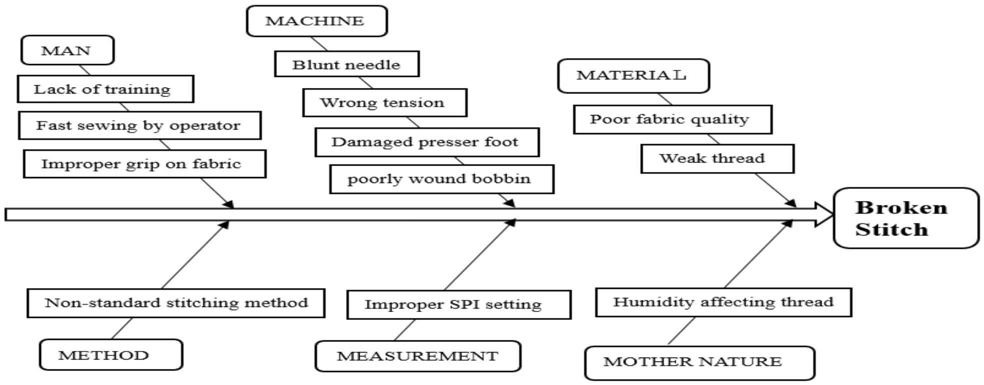


Figure 2. Fishbone Diagram for Broken Stitch

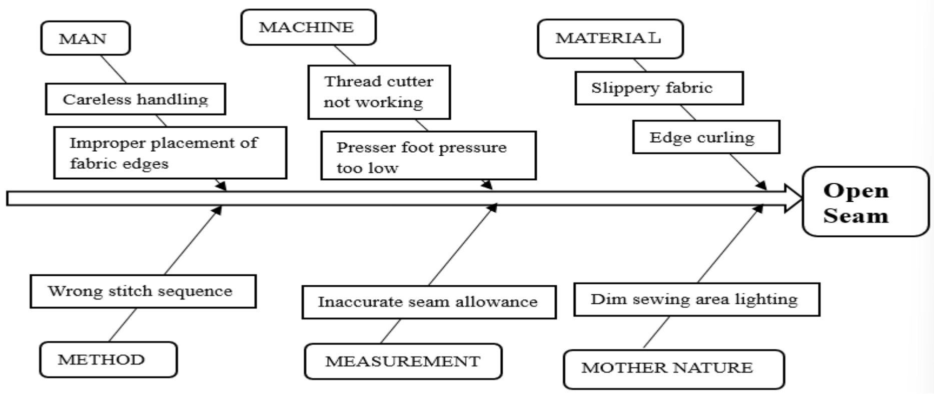


Figure 3. Fishbone Diagram for Open Seam

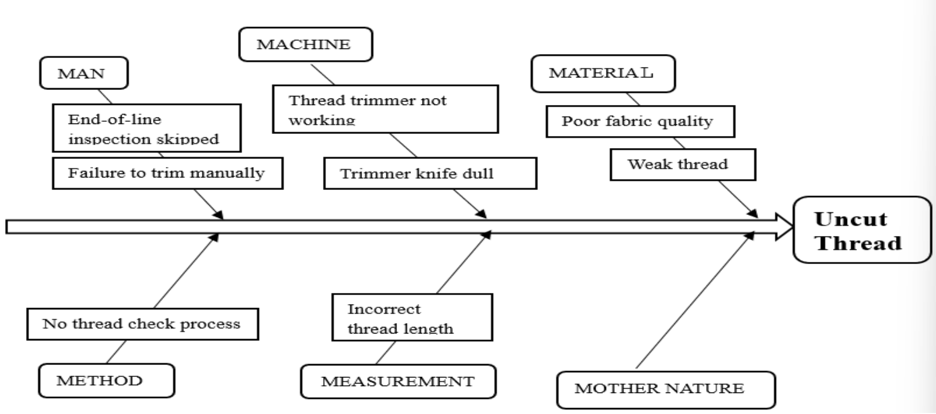


Figure 4. Fishbone Diagram for Uncut Thread

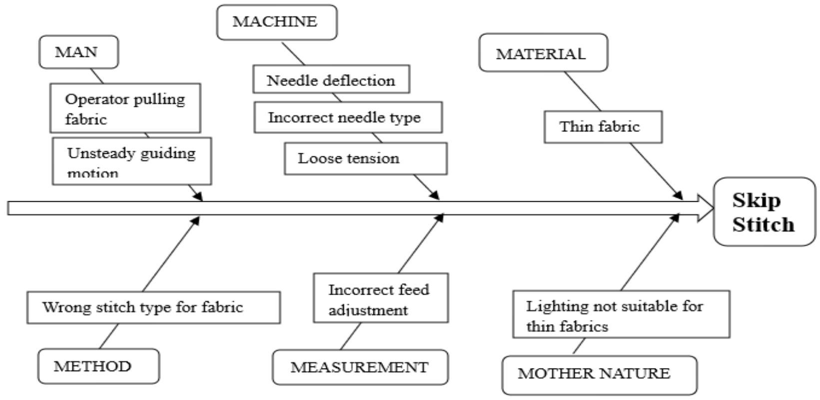


Figure 5. Fishbone Diagram for Skip Stitch

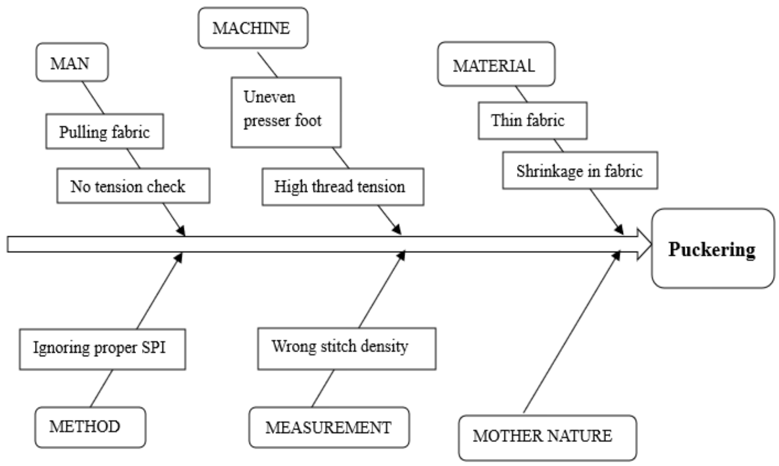


Figure 6. Fishbone Diagram for Puckering

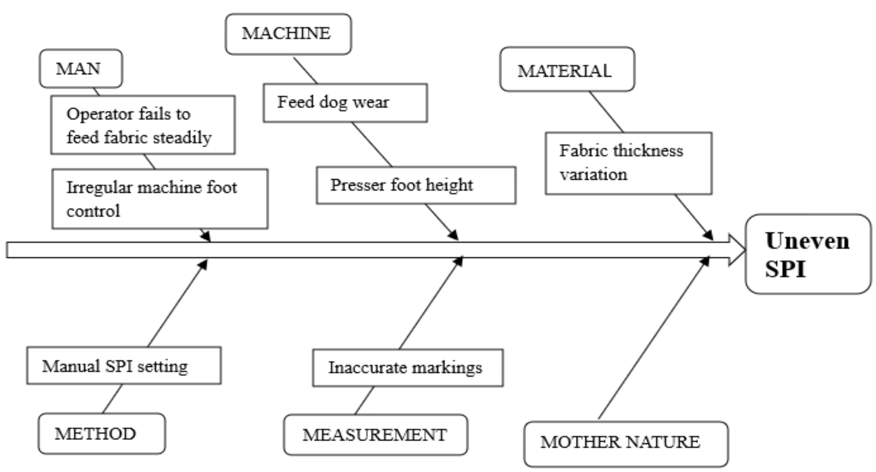


**Figure 7**. Fishbone Diagram for Uneven SPI

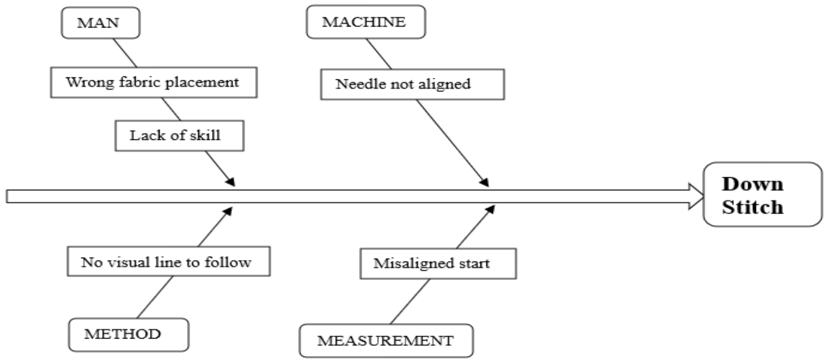


Figure 8. Fishbone Diagram for Down Stitch

The detailed analysis of fishbone diagrams for all seven defects is demonstrated in Table 2. This table directly links each defect to its specific root causes and the significant corrective actions that were implemented for improvement in sewing section.

Table 2. Root Causes and Corrective Actions for Major Defects in Sewing Sections (Line-10, unit-6)

| Defect Type | Root Cause (Grouped by 6M) | Corrective Action Taken |
|---|---|---|
| **Broken Stitch** | **Man**: Lack of operator training, high-speed sewing, poor grip<br>**Machine**: Blunt needle, rusty foot, poor bobbin<br>**Method**: No standard stitch method<br>**Material**: Weak thread/fabric<br>**Measurement**: Wrong tension/SPI | Operators retrained; speed limited to standard range; needle changed daily; presser foot cleaned every shift; tension checked before start; thread upgraded; |
| **Open Seam** | **Man**: Careless edge handling<br>**Machine**: Thread cutter fault, low pressure<br>**Method**: Wrong stitch order, seam gap<br>**Material**: Slippery/curling fabric<br>**Environment**: Poor lighting | Quality Control staff guided operators; edge folder used; thread cutter repaired; pressure adjusted; seam allowance marked; proper light placed in those zones |
| **Uncut Thread** | **Man**: Skipped trimming, not trimmed manually<br>**Machine**: Dull trimmer<br>**Method**: No thread check<br>**Material**: Weak thread<br>**Measurement**: Extra thread length | End line checkers made mandatory; trimming awareness meeting held; trimmer sharpened weekly; thread length minimized from spool; pre-final audit checklist updated |
| **Skip Stitch** | **Man**: Pulling fabric, irregular guiding<br>**Machine**: Wrong needle, loose tension<br>**Method**: Wrong stitch for fabric<br>**Material**: Thin/delicate fabric<br>**Environment**: Low light | Instructed to operators not to pull fabric; tension test made daily; thin fabric needle used; proper light placed in those zones |
| **Puckering** | **Man**: Pulling fabric<br>**Machine**: Uneven foot pressure<br>**Method**: No tension check, SPI ignored<br>**Material**: Shrinkage, no stabilizer<br>**Measurement**: High tension, wrong stitch density | Operators trained not to stretch fabric; pressure set properly; SPI setting done per fabric GSM; tension checked before each style; |
| **Uneven SPI** | **Man**: Unsteady feed, bad foot control<br>**Machine**: Faulty feed dog<br>**Method**: Manual SPI not calibrated<br>**Material**: Thickness variation | Operators given fabric feed practice; foot pedal serviced; feed dog changed; SPI set with dial gauge; line QC checked SPI every 2 hours |

| Defect Type | Root Cause (Grouped by 6M) | Corrective Action Taken |
|---|---|---|
| | **Measurement**: Bad fabric marking | |
| **Down Stitch** | **Man**: Wrong fabric placement, skill gap<br>**Machine**: Needle misaligned<br>**Method**: Start point error<br>**Environment**: No visual guide | Operators given demo on alignment; needle bar adjusted; starting point guide marked; transparent ruler used; sticker line added on machine bed |

Table-2 clearly illustrates the links between defects and their possible root causes and corrective measures taken. We designed these initiatives to be low-cost, quick to implement, and easy to follow by operators and helpers. After implementing these actions, the January defect trend was analysed to assess their effectiveness, which is explained in the next section.

## 5.4. Improvement Implementation and Impact Analysis

To put our root cause analysis into action, we used the PDCA (Plan-Do-Check-Act) cycle as our guide for implementing Kaizen. This structured approach ensured our improvements were organized and effective.

- **Plan**: We developed specific action plans based on the root causes we identified in **Table 2**. For example, the plan to fix Broken Stitch included operator retraining, daily needle changes, and thread upgrades.
- **Do**: In January 2025, we executed these plans on the production floor, including operator retraining, machine adjustments, and the introduction of visual guides.
- **Check:** We closely monitored the results by tracking daily production, defect rates, and line efficiency throughout January. This allowed us to see if our actions were working.
- **Act**: Successful changes, such as the new needle change protocol and updated SOPs, were standardized to sustain the improvements.

Following this PDCA cycle, we analyzed the comprehensive impact of these changes on both production efficiency and product quality. Our selected production line operated with 32 workers on 8-hour shifts (480 minutes) and had a Standard Minute Value (SMV) of 7.12 minutes per polo shirt. Line efficiency and defect rate were calculated using Equations 1 and 2, respectively. The impact of the kaizen changes is shown in Table 3, which compares performance before (Oct – Dec) and after implementation (January).

Table 3. Daily Production, Efficiency, and Defect rate Summary (October–December 2024, January 2025)

| Month | Avg Production (pcs/day) | Avg Efficiency (%) | Avg Defect rate (%) |
|---|---|---|---|
| Oct - Dec | 796 | 36.89 | 24.26 |
| January | 863 | 40 | 15.54 |

As shown in Table 3, the Kaizen implementation increased daily production by 67 pieces and improved line efficiency from 36.89% to 40.00%. Most significantly, the defect rate was reduced by 8.72%. The success of the Kaizen initiative is visually summarized in Figure 9.

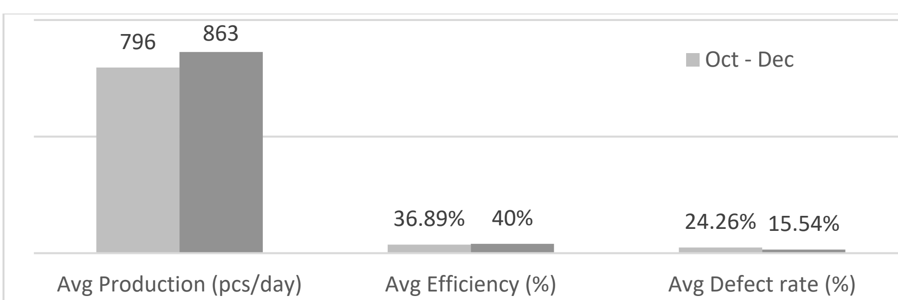


Figure 9. Comparison of Key Performance Metrics Before and After Kaizen Implementation

### 5.5 Statistical Validation of Improvements

Hypothesis testing was used to determine if the observed improvements in defect rate and efficiency were statistically significant. Our goal was to confirm that the recorded improvements in January 2025 (post-Kaizen) compared to the baseline period of October–December 2024 (pre-Kaizen) were statistically meaningful rather than due to random variation.

### 5.5.1 Hypothesis Testing for Defect Rate Reduction

To evaluate whether the Kaizen implementation significantly reduced the average number of defects in polo shirt production, a pooled t-test was applied. Since the true population standard deviations were unknown, the sample standard deviations were used to estimate them under the assumption of equal variances.

Step-1: State null and alternative hypothesis:

$H_0: \mu_a \geq \mu_b$ (Pre-Kaizen: no changes in defect rate)

$H_1: \mu_a < \mu_b$ (post-Kaizen: reduction in defect rate after Kaizen)

Where:

- Sample mean before implementation, $X_b = 256.35$
- Sample mean after implementation, $X_a = 158.77$
- Standard deviation before implementation, $S_b = 29.71$
- Standard deviation before implementation, $S_a = 16.61$
- Sample size before implementation, $n_b = 78$
- Sample size before implementation, $n_a = 26$

Step-2: Level of significance

$\propto = 0.05$

Step-3: Test statistics:

The Pooled *t*-test: Unknown Population Standard Deviations

Step-4: Rejection rule:

Reject $H_0$ if, $t < t_\propto$

The pooled variance was computed as:

$$sp^2 = \frac{(n_b - 1)\,(s_b)^2 + (n_a - 1)\,(s_a)^2}{(n_b + n_a) - 2}$$

$$= \frac{(78-1)\,(29.71)^2 + (26-1)\,(16.61)^2}{78+26-2} = = 733.651$$

The test statistic was then calculated as:

$$t = \frac{x_a - x_b}{\sqrt{Sp^2\,(\frac{1}{n_b} + \frac{1}{n_a})}} = \frac{158.77 - 256.35}{\sqrt{733.651(\frac{1}{78} + \frac{1}{26})}} = -15.915$$

Step-5: Conclusion:

Since the calculated value, $t = -15.915$ is far less than the critical value (–1.66), the null hypothesis is rejected. This confirms that the reduction in the mean number of defects after Kaizen implementation was statistically significant, supporting the effectiveness of the improvement initiatives in reducing sewing defects in polo shirt production.

### 5.5.2 Hypothesis Testing for Efficiency Improvement

To examine after the Kaizen implementation for average line efficiency, a pooled t-test was applied. Since the population standard deviations were unknown, the sample standard deviations were used under the assumption of equal variances.

Step - 1: State null and alternative hypothesis:

$H_0: \mu_a \leq \mu_b$ (Pre-Kaizen: no improvement in efficiency)

$H_1: \mu_a > \mu_b$ (post-Kaizen: efficiency is higher)

Where:

- Sample mean before implementation, $X_b = 0.37$
- Sample mean after implementation, $X_a = 0.40$
- Standard deviation before implementation, $S_b = 0.01$
- Standard deviation before implementation, $S_a = 0.02$
- Sample size before implementation, $n_b = 78$
- Sample size before implementation, $n_a = 26$

Step - 2: Level of significance

$\propto = 0.05$

Step - 3: Test statistics:

The Pooled *t*-test: Unknown Population Standard Deviations

Step - 4: Rejection rule:

Reject $H_0$ if, $t > t_{\propto,\ df}$

The pooled variance was computed as:

$$Sp^2 = \frac{(n_b-1)sb^2+(n_a-1)Sa^2}{(n_b+n_a)-2} = \frac{(78-1)\ (0.01)^2+(26-1)\ (0.02)^2}{78+26-2}$$

$$= 0.00017353$$

The test statistic was then calculated as:

$$t = \frac{x_a - x_b}{\sqrt{Sp^2\ (\frac{1}{n_b}+\frac{1}{n_a})}} = \frac{0.40 - 0.37}{\sqrt{0.0001735\ (\frac{1}{78}+\frac{1}{26})}} = 10.06$$

the critical t-value at a 5% significance level (one-tailed) is approximately:

$$t_{0.05,102} = 1.66$$

Step-5: Conclusion**:**

Since the calculated value t = 10.06 > 1.66, the null hypothesis is rejected. There is sufficient evidence at the 5% significance level to conclude that the average line efficiency after Kaizen implementation is significantly higher than before

## 6. Results and Discussion

The data clearly shows that our initiative was a success. After implementing the changes in January 2025, the production line showed strong improvements across our targeted areas. Daily output increased from 796 to 863 pieces, and line efficiency rose from 36.89% to 40.00%. Most importantly, the quality of our polo shirts improved significantly, with the defect rate dropping from 24.26% to 15.54%, as evident in Table 3. To ensure these positive improvements were from our efforts and not just random chance, we conducted statistical tests. The tests for both defect reduction and efficiency improvement provided us solid evidence that our improvements were real and statistically significant. This means we can be over 95% confident that the Kaizen actions directly led to these better results.

This success was made possible by our DMAIC structured approach. The Pareto analysis helped us to target the right problems, while the Fishbone diagrams uncovered the root causes, like blunt needles and untrained operators. Then using the PDCA cycle to guide our implementation, we ensured that solutions like daily needle changes and operator retraining were applied effectively. Our experience confirms what other researchers have found, that training operators and standardizing processes are key to better quality and productivity **(Jagdeep & Harwinder 2012**). However, our project adds something new. By bringing all these tools together under the full Lean Six Sigma DMAIC method and proving the results with statistical tests, we have created a clear and reliable model that other knitwear factories can use confidently.

## 7. Conclusion and Future Research

This conclusion summarizes our journey of using the Lean Six Sigma DMAIC method to solve quality and efficiency problems in our polo shirt production line. Our first goal was to find the main defects in the sewing and finishing sections. We achieved this by using a Pareto analysis, which identified the seven most common defects in our polo shirt production. We then used Fishbone diagrams to understand the root causes of these problems. Our second goal was to lower the defect rate and make the line more efficient. The results show we succeeded. After making changes through Kaizen, the defect rate dropped significantly. At the same time, our daily production increased and line efficiency improved. Statistical tests proved these changes were real and not just luck. The main lesson from our project is that this structured approach works well for knitwear factories. The changes we made in the sewing and finishing sections for polo shirts, like better training and machine care, were simple and low cost. This shows that other factories can also use this method to get better results. We should mention that this study was done on one production line for polo shirts. For future work, we recommend trying this same method on other lines and for different knit products. It would also be helpful to track the long-term savings from these quality improvements.

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