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# SOP-Driven Improvements in Efficiency, Quality and On-Time Delivery: Evidence from Bangladesh's RMG Sewing Industry

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## Abstract

The Ready-Made Garments (RMG) industry in Bangladesh is highly dependent on operational efficiency, product quality and on-time delivery to maintain competitiveness in the global apparel market. While many studies focus on holistic Quality Management Systems (QMS), an empirical gap exists in quantifying the isolated impact of basic Standard Operating Procedure (SOP) enforcement on core production metrics. This study investigates the effect of SOP implementation - without integrating the Plan-Do-Check-Act (PDCA) cycle or other external quality models - on performance within the sewing and quality sections of a leading Bangladeshi RMG factory. A pre- and post-implementation analysis was conducted using key performance indicators (KPIs) such as efficiency, Non-Production Time (NPT), Handover on Time (HOT), defect rates and Defects per Hundred Units (DHU). All observed improvements were statistically significant at $p < 0.05$, confirming the measurable effect of SOP enforcement. Findings reveal a significant, immediate step-change in operational performance, demonstrating the technical contribution of process discipline. Production efficiency increased from approximately 67.9% to 77.9%, HOT achieved 100% on-time delivery, NPT reduced substantially (from 32% to 22.05%) and DHU rates dropped sharply (from 9.96% to 5.21%) due to standardized workflows and multi-stage quality checkpoints. These empirical results provide clear evidence that SOPs are a powerful, standalone lever for operational excellence. As the analysis is based on data from a single factory, the findings may not be broadly generalisable, although they provide useful evidence of SOP-driven improvements in similar production environments.

## Keywords
Standard Operating Procedure (SOP), Quality Management System (QMS), Handover on Time (HOT), Non-Production Time (NPT), Defects per Hundred Units (DHU), Efficiency.

## 1. Introduction
The Ready-Made Garments (RMG) industry remains the backbone of Bangladesh's economy, contributing more than 80% of export earnings and employing millions of workers across the country (Khaled & Ansar, 2024). In an increasingly globalized and competitive market, RMG manufacturers face mounting pressure to deliver defect-free garments, meet demanding lead times and maintain compliance with stringent buyer requirements. The post-pandemic era has further emphasized the need for operational resilience; disruptions in procurement, production and logistics have led to shipment delays and reduced profit margins in Bangladesh's RMG sector (Habib et al., 2025). In many Bangladeshi garment factories, DHU (Defects per Hundred Units) levels in the sewing section often range between 2% and 5%, especially where quality assurance practices are weak (A. Hossain et al., 2018).These factories had been facing inconsistent quality levels, high rework costs and frequent Handover on Time (HOT) misses, causing productivity loss and delays in order fulfillment.

To address these challenges, Standard Operating Procedures (SOPs) have emerged as a cornerstone of process control and quality assurance in modern garment manufacturing. An SOP framework typically includes step-wise process flows, inspection checklists, quality control points and guidelines for Standard Minute Value (SMV) planning and manpower allocation to maintain consistent productivity. More recently, industry reports have demonstrated that factories adopting comprehensive Quality Management Systems (QMS) integrated with SOPs have experienced reductions in product rejection rates and significant improvement in on-time delivery (Shubham, 2025). By embedding traceability, accountability and continuous improvement mechanisms, SOPs go beyond compliance - they create a disciplined production environment capable of adapting to volatile buyer demands.

However, despite the recognized importance of SOPs, few empirical studies in the Bangladeshi RMG sector have quantified their isolated impact on operational performance indicators such as efficiency, rework and HOT (Mehnaz Jebin et al., 2024). Most existing literature combines SOPs with complex frameworks like Lean, Six Sigma or PDCA, making it difficult to assess the standalone technical contribution of process standardization. This study addresses that critical empirical gap. The technical contribution of this research is two-fold: first, to quantify the immediate and significant "step-change" in operational capability (mean and stability) attributable solely to the disciplined enforcement of SOPs; and second, to provide an integrated KPI analysis linking process discipline (DHU, NPT) directly to business outcomes (Efficiency, HOT). This study draws on a complete SOP manual from a leading RMG factory in Bangladesh, covering its quality system, cutting section, sewing section and inspection protocols. Specifically, it addresses two guiding research questions:

***RQ1.*** To what extent does SOP implementation improve production efficiency, product quality and HOT, as measured through key operational metrics?
***RQ2.*** How does integrating ISO-aligned SOPs with company procedures improve manpower utilization, earned hours and output?

Through the integration of quality checkpoints, fabric relaxation protocols and collaborative pre-production meetings, this research demonstrates measurable improvements in efficiency and delivery performance, suggesting a likely reduction in rework rates and strengthen buyer relationships. Frameworks such as PDCA, Lean, or Six Sigma were not integrated in this study in order to isolate the direct operational impact of SOPs, a gap often overlooked in prior research. This research not only bridges a critical empirical gap in the literature but also offers data-driven, actionable insights for practitioners seeking to optimize efficiency and HOT performance, thereby reinforcing Bangladesh's position in the global apparel value chain.

### 1.1 Objectives

The key objectives of this research are:

(i) to analyze the design and implementation of the SOP framework and
(ii) to measure its impact on efficiency, product quality, manpower utilization and HOT performance.

The remainder of the paper is organized as follows: Section 2 reviews relevant literature, Section 3 details the methodology and SOP framework, Section 4 presents results and discussion, and Section 5 concludes with recommendations and future research directions.

## 2. Literature Review

### 2.1 Standard Operating Procedures in Manufacturing

Process standardization via SOPs is widely recognized as a mechanism for minimizing human error, improving consistency and enhancing overall operational performance (Nissinboim & Naveh, 2018). In apparel supply chains, traceability is increasingly required for compliance and provenance, yet adoption remains limited (Colombage & Sedera, 2025); occupational safety compliance in Bangladeshi textile factories is monitored through inspections and buyer-driven standards (Karanikas & Hasan, 2022); and buyer compliance regimes and audits are institutionalized through multi-stakeholder initiatives post-Rana Plaza (Fontana & Dawkins, 2024).

### 2.2 Quality Management Systems in RMG

The ISO 9001:2015 Quality Management System (QMS) emphasizes a process approach, customer focus, and continual improvement. Implementing ISO-aligned SOPs ensures that production processes are planned, monitored, and improved systematically (Kunanti et al., 2024).

In Bangladesh's RMG sector, quality-focused SOPs reduce defects and enhance delivery performance. Integrating the PDCA cycle ensures continuous improvement through iterative feedback loops (Tahiduzzaman et al., 2018).

### 2.3 Fabric Inspection Standards

The 4-Point Fabric Inspection System is the global standard for evaluating textile quality. Developed by the American Apparel Manufacturers Association, this method assigns demerit points based on defect severity, ensuring uniform defect detection and grading. Its integration into SOPs enables early detection of material faults before they impact downstream processes (A. K. M. M. Hossain & Islam, 2023).

### 2.4 Cutting Section as a Critical Stage

The cutting stage directly influences garment fit, seam alignment and fabric utilization efficiency. Evidence from Bangladesh indicates that cutting generates a substantial share of fabric waste and contributes to cut-panel rejections; strengthening marking, spreading, and cutting SOPs reduces downstream quality problems and supports delivery performance. Consequently, precise cutting SOPs with inspection steps and material handling protocols are crucial.

### 2.5 Sewing Section as a Main Stage

The sewing section is frequently regarded in the literature as one of the most critical stages for maintaining garment quality and achieving high productivity. In Bangladesh, several studies show that sewing defects - including skip stitches, broken stitches and loose threads - are among the top contributors to rework and reject rates. For instance, Tahiduzzaman et al. (2018) reduced sewing defects significantly by applying lean tools (5S and PDCA) in a knit T-shirt factory, identifying that about 80% of sewing defects originated from a few recurring defect types and sub-stations. Another recent study by Lingkon et al. (2024) integrated sewing defect reduction with productivity enhancement, showing measurable gains in efficiency through correcting major defects using Pareto and root cause analysis.

### 2.6 Quality Section

The quality section plays a pivotal role in ensuring defect-free output by implementing in-line and end-of-line inspections, DHU monitoring and corrective action processes. Effective quality control systems help to reduce rework, improve right-first-time (RFT) rates and strengthen buyer confidence. Factories adopting structured quality checkpoints and data-driven DHU analysis significantly lowered rejection rates and improved shipment compliance (A. Hossain et al., n.d.).

### 2.7 Finishing Section

The finishing section is the final stage of garment production, involving thread trimming, ironing, tagging, folding, and packing to prepare garments for buyer inspection and shipment. Efficient finishing operations are essential for meeting delivery deadlines and avoiding shipment delays. Delays in finishing and packing contribute significantly to extended lead times and improving workflow standardization in this stage can reduce order cycle times (Khan, 2021).

## 3. Research Methodology

This study focuses on improving efficiency, maintaining quality, and reducing production delays in the Bangladeshi Ready-Made Garments (RMG) industry through the use of SOPs. SOPs are written, step-by-step instructions that guide workers in performing tasks consistently and correctly. They help ensure that every stage of garment production - from fabric preparation to shipment - is well organized, monitored, and standardized. In this research, the main focus is on the sewing section, since it is the most critical stage where cut fabric panels are transformed into garments and where most quality problems usually occur (Alam & Huda, 2018). By organizing and analyzing the SOPs of embroidery, sewing, quality inspection, and rectification, this methodology provides a systematic approach to enhancing both efficiency and quality in the factory. The SOP set used in this study was designed by integrating the factory's existing ISO-aligned procedures with buyer-compliance requirements. These SOPs were validated through cross-functional reviews involving production, quality, and industrial engineering teams to ensure consistency, feasibility, and replicability.

### 3.1 Factory Process Flow

The general workflow in the factory begins with the receiving of raw materials in the store. Figure 1. shows the flow chart of factory process flow. If needed, yarn is dyed before being knitted into fabric. The knitted fabric then goes through dyeing and finishing processes. After fabric finishing, the material enters the cutting section, where garment panels are shaped according to patterns.

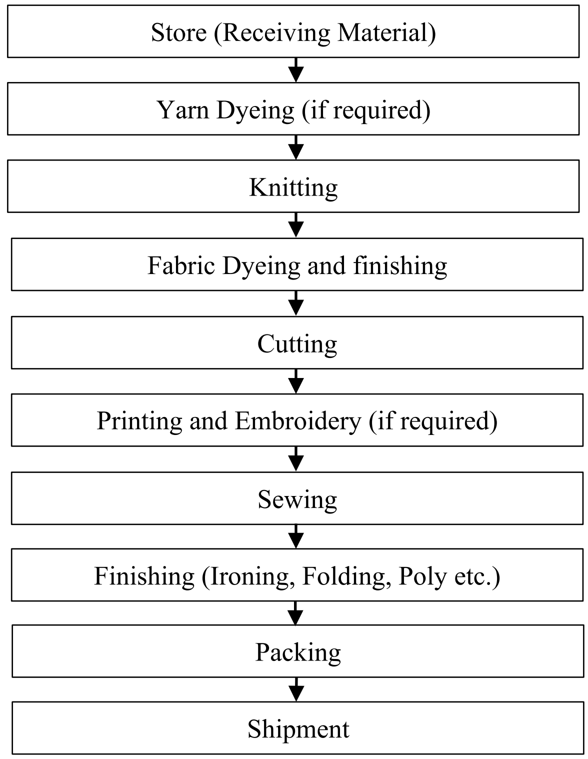


Figure 1. Factory Process Flow

Some garments require printing or embroidery at this stage before moving to the sewing section. The sewing section is the heart of the factory, where panels are stitched together to form garments. After sewing, garments go through finishing processes such as ironing, folding, and packaging, and finally they are packed and shipped to buyers. This flow provides the foundation for SOP design, ensuring that every department knows its role and follows standardized procedures.

### 3.2 Pre-Sewing Preparation

Before production, the sewing lead verifies the style risk analysis, PP meeting report, and approved trims/samples; sets the machine layout; briefs operators; and stages required accessories. Six pilot pieces are stitched to confirm measurements, the line is cleared of WIP and approved bundles move to finishing. Accessories are inspected and tested (e.g., button pull, shrinkage, twist, color fastness), followed by a final clockwise inspection to ensure no defects are missed.

### 3.3 Sewing Section SOPs

The sewing section transforms cut fabric panels into complete garments. This is the most important part of production and requires careful planning and monitoring. The process begins with collecting approved samples, trim cards, and cut pieces. All pieces are measured to confirm accuracy before sewing starts. Special care is taken for light-colored garments, which must be stored in poly bags to avoid stains. Each sewing machine has a mock-up sample attached for operator reference. Quality checks are done by inspecting seven random pieces from each operation, and results are reported using the traffic light system. If a defect is found, the line is stopped and corrected immediately by production and quality staff.

### 3.4 General Sewing Line Procedure

The sewing line must remain orderly and clean, with inputs transferred via challan and recorded at each step. Operators use required PPE (gloves, eye/needle guards), track cutting numbers to prevent shade variation, verify needle types against buyer specs, keep WIP minimal to avoid bottlenecks, and routinely check machine settings; in any needle breakage, all pieces are recovered before replacement. Supervisors ensure accurate input–output records and proper order closure.

### 3.5 Quality Assurance and Rectification SOPs

Quality on the sewing line is enforced through SOPs: defective pieces never pass to finishing; end-table inspectors and supervisors correct immediately. Cut parts are checked against guides, defects analyzed by zones, and cutting consulted when needed. Mockups guide new styles. Traffic-light reports are updated; production can stop for repeats. Corrected items are rechecked. A first-output inspection examines 50 garments - QA compares styling, trims, seams, and measurements to approved sample/tech pack; bulk cutting resumes after fixes. On the end line, checks mark defects with red arrows, rework or reject, and report to QC. DHU quantifies defects (e.g., 35/200 = 17.5%) for clarity (Patil et al., 2018).

### 3.6 Hourly Quality Control

Quality control is performed every hour by checking seven garments from each operation. If a defect is found, the operator receives a verbal warning. Repeated defects lead to a yellow card, and serious issues result in a red card with immediate corrective action. Bundle charts are used to track work and garment measurements are checked twice daily. Hourly reports are maintained, and if the defect rate exceeds three percent, the QA Manager and Production Manager are notified. All defects must be repaired within the same hour to keep production smooth.

### 3.7 Data Collection

Data were collected from production monitoring systems, quality control logs, and shipment performance reports. A one-month pre-implementation period (July) and a one-month post-implementation period (August) were selected to ensure stability and comparability in production conditions and buyer orders. Key performance indicators (KPIs) tracked included:

Non-Production Time (NPT) = Total downtime (minutes) during shifts due to waiting, line balancing delays, or machine stoppages.

$$\text{Efficiency (\%)} = \frac{Earned\ Hours \times 100}{Working\ Hours} \quad (1)$$

$$\text{HOT (\%)} = \frac{Actual\ Shipment\ Quantity \times 100}{Required\ Shipment\ Quantity} \quad (2)$$

$$\text{DHU (\%)} = \frac{Total\ Defects\ Found \times 100}{Total\ Units\ Checked} \quad (3)$$

$$\text{Sewing Output Performance (\%)} = \frac{Output\ Quantity \times 100}{Target\ Quantity} \quad (4)$$

All KPIs were measured for a one-month pre-implementation period and a one-month post-implementation period to allow comparative analysis. Table 1 shows the performance data before SOP implementation.

Table 1. Pre-Implementation Performance Data (Avg.) of Sewing Line Operations (July 1 – July 31)

| Parameters | Value |
|---|---|
| SMV | 4.99 min. |
| Total manpower | 6,342 |
| Total working hour | 63,420 hr. |
| Total earn hour | 43,060 hr. |
| Target (pcs) | 5,81,489 |
| Output (pcs) | 5,17,752 |
| Efficiency | 67.9% |
| Performance | 89% |
| DHU | 9.96% |
| NPT | 32% |
| Shipment qty (Required) | 5,30,000 |
| Shipment qty (Actual) | 5,14,260 |
| HOT | 87% |

### 3.8 Data Analysis

The data analysis employed a Pre- and Post-Intervention Step-Change Analysis (SCA) to isolate the effect of the SOP implementation, as the single, distinct intervention between the two periods. The immediate shift in the time-series data (Figure 2 and Figure 7) and the distributional changes (Figure 3) serve as the primary evidence of the SOP's impact. Quantitative analysis involved comparing KPI values before and after SOP deployment. Statistical significance was confirmed using a two-sample t-test ($p < 0.05$) which indicated that the change in the mean values for Efficiency, DHU, NPT and HOT were all statistically significant between the two periods. Graphical analyses were used to visualize pre- and post-SOP performance trends. A size-set sample is prepared using actual trims and fabrics and reviewed for alignment with buyer requirements; once approved, a pre-production (PP) meeting is held to communicate risks and requirements across functions before bulk production. For critical operations, mockups and standardized work/visual aids are deployed at the line to prevent errors and ensure consistency. Table 2 shows the performance data after SOP implementation.

Table 2. Post-Implementation Performance Data (Avg.) of Sewing Line Operations (August 1 – August 31)

| **Parameters** | **Value** |
|---|---|
| SMV | 5.51 min. |
| Total manpower | 5,534 |
| Total working hour | 55,340 hr. |
| Total earn hour | 43,140 hr. |
| Target (pcs) | 4,95,114 |
| Output (pcs) | 4,70,181 |
| Efficiency | 77.9% |
| Performance | 94.96% |
| DHU | 5.21% |
| NPT | 22.05% |
| Shipment qty (Required) | 4,58,500 |
| Shipment qty (Actual) | 4,67,930 |
| HOT | 100% |

### 3.9 Integration of SOPs

By integrating these SOPs into the production system, the factory benefits in several ways. Processes become consistent, quality checks detect defects early, and operators receive clear guidance on expectations. Visual monitoring systems such as the traffic light method provide quick feedback, while measures like DHU offer numerical insights into quality. Together, these systems reduce rework, save time and ensure timely delivery to buyers. This methodology demonstrates how structured SOPs in sewing, and quality inspection can improve efficiency, reduce defects, and shorten turnaround times in garment production. By standardizing operations and enforcing accountability at every stage, factories can achieve better quality control and more reliable production schedules. The approach not only strengthens buyer confidence but also improves the global competitiveness of the Bangladesh's RMG industry.

## 4. Results and Discussion

The implementation of SOPs brought notable changes in the factory's performance, particularly in the sewing section where most quality issues arise. Efficiency levels improved, non-production time decreased, and shipment deadlines were consistently met. Defect rates and DHU percentages were also reduced, leading to better product quality and fewer reworks.

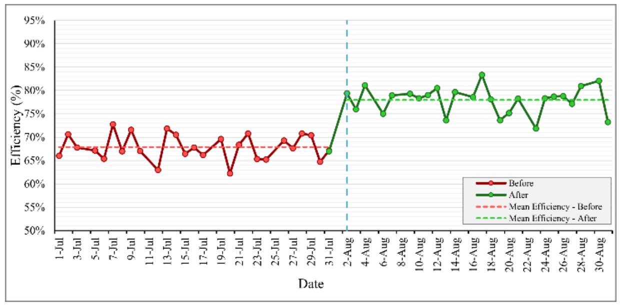


Figure 2. Daily line efficiency (%) with SOP

These outcomes highlight the role of SOPs in creating a more stable, organized, and accountable production environment. The following discussion connects these results with practical factory operations and explains how standardized procedures supported both productivity and buyer satisfaction.

Figure 2 plots daily efficiency and marks the intervention date. The series exhibits a clear step change at SOP go-live rather than a gradual drift, indicating an intervention effect. The post-SOP mean increases by ~10 percentage points (from 67.9% to 77.9%), and the post-period trajectory maintains higher values with fewer low outliers, suggesting improved process capability/stability. These patterns are consistent with the pre–post distributions in Figure 3.

Figure 3 summarizes the distributional change in KPIs after SOP implementation. The median Efficiency rises from ~68% to ~78%, with the lower tail notably lifted, and Performance moves from ~91% to ~95%. On the quality side, DHU drops from ~9.5% to ~5.2%, with fewer and smaller high-end outliers, and NPT declines from ~32% to ~22%. These shifts higher centers and tighter spreads indicate both level improvement and greater stability of the production system, consistent with the time-series step change in Figure 2 and the cumulative plan adherence in Figure 5.

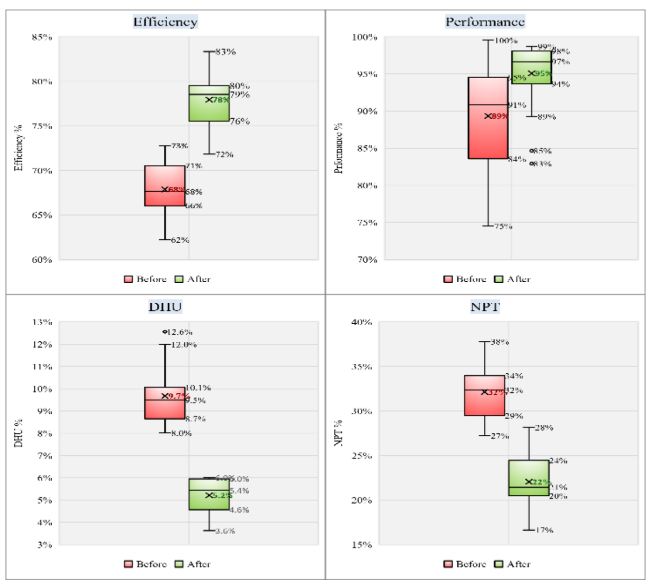


Figure 3. Pre–post distributions of four key KPIs following SOP deployment

Figure 4 compares daily output with earned time before and after the SOP implementation (n=32 for each phase). After implementing the SOPs, the output consistently improved for the same amount of earned time. The fitted line for the post-SOP phase shows a small positive slope (+1.78 per x-unit), while the pre-SOP line was either flat or had a slight negative slope (-2.79). The primary interpretation of this figure is the upward displacement of the post-SOP data cluster, indicating that for similar earned hours, the factory produced a higher volume of finished goods.

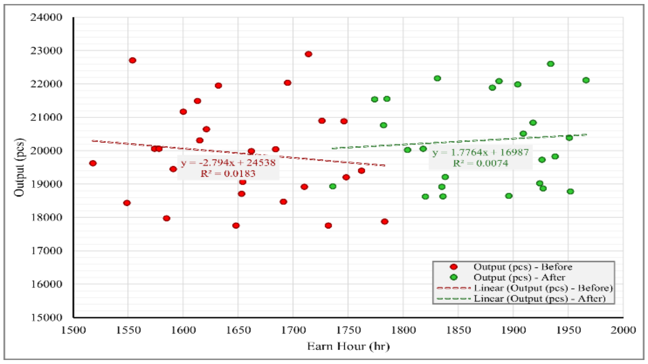


Figure 4. Output vs earned time, pre–post SOP

This strongly supports RQ2, demonstrating improved manpower utilization by converting the same effort (earned hours) into greater output. The weak $R^2$ values are expected - daily output also depends on factors like manpower mix, line balance, and NPT but the upward displacement of the post-SOP points aligns with the efficiency gains in Figure 2 and Figure 3.

Before SOP, HOT averages ~96–97% with a few dips to ~91–93% and visible variability. Immediately post-SOP it rises to 100% and stays flat across all observed days, indicating tighter handover planning and schedule adherence, which is shown in Figure 7.

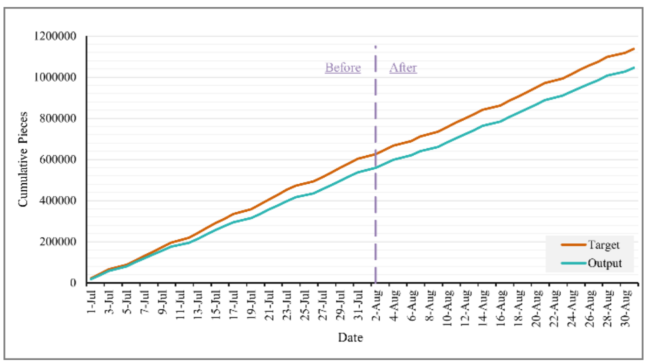


Figure 5. Cumulative target vs. output with SOP go-live

The cumulative curve in Figure 5 shows a clear improvement after SOP: output climbs faster and tracks the target more closely, reducing the cumulative shortfall through August. This pattern corroborates the step-change in efficiency (Figure 2) and the distribution shifts in Figure 3.

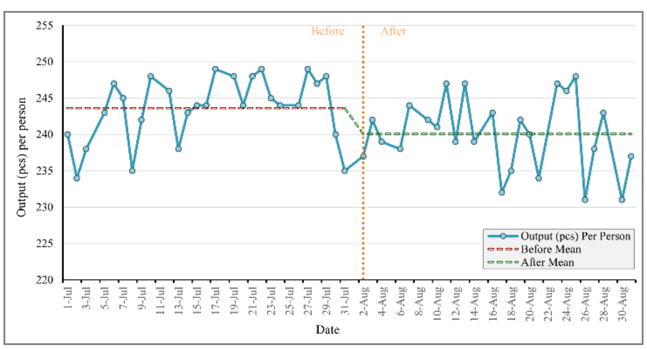


Figure 6. Output per person (OPH) by day with SOP

Figure 6 shows that Output per Hour (OPH) remains relatively stable, ranging from around 230 to 250 pieces per person in both phases. The average OPH after SOP implementation is about 240, compared to 243 before SOP (a decrease of approximately 3 pieces, or around -1%). This counter-intuitive finding reinforces the core argument: the gains in overall efficiency (Figure 2) and reduction in DHU (Figure 3) did not come from simply speeding up operators (which would raise OPH) but from reducing non-productive time and rework, thereby increasing the effective time spent on value-added tasks.

The 10-percentage increase in efficiency (from 67.9% to 77.9%) is comparable to or exceeds improvements reported by previous studies integrating complex frameworks. For example, studies applying Lean principles combined with PDCA cycles (Lingkon et al., 2024; Tahiduzzaman et al., 2018) reported efficiency gains, but our findings show that standardized procedures alone can deliver significant, immediate gains by stabilizing the process (reduced NPT from 32% to 22%) and reducing hidden factory time (rework). The drop in the DHU rate from 9.96% to 5.21% moves the factory closer to the industry-benchmark range addressed in (A. Hossain et al., n.d.), validating that the multi-stage quality checkpoints embedded in the SOPs effectively reduced defects at the source, rather than just detecting them later. The 100% HOT performance post-SOP is a direct operational outcome of improved quality and reduced delays in the sewing section, minimizing bottlenecks in the final stages.

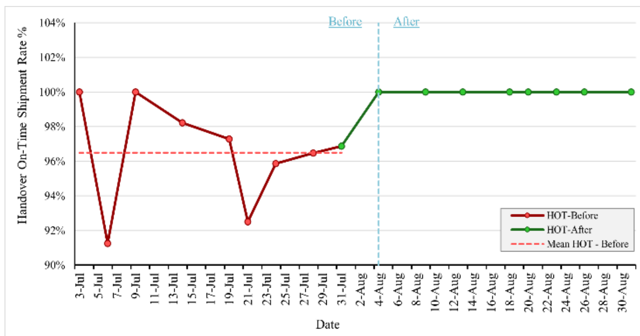


Figure 7. Handover on-time shipment rate (HOT) by day

## 5. Conclusion

The implementation of SOPs in the Bangladeshi RMG industry demonstrably improved core operational metrics by standardizing work, stabilizing flow and enforcing schedule discipline. In this study, efficiency rose from approximately 67.9% to 77.9%; NPT and defects (including DHU) decreased; and HOT and shipment performance reached 100%, indicating right-first-time output and on-time delivery. This robust empirical evidence confirms the technical contribution of process standardization as a powerful, non-complex lever for operational excellence. These gains reflect fewer errors and reworks, tighter alignment with buyer requirements, and a more predictable, agile production system strengthening productivity, quality and customer satisfaction while enhancing competitiveness in a demanding global market. The structured, repeatable practices embedded in SOPs created clearer accountability and faster feedback loops across cutting, sewing, finishing and shipment planning, fostering a culture of consistency and continuous improvement.

This evidence, however, has limitations. Since this study was conducted in one factory, generalisability is limited. Performance outcomes may vary across factories with different operational maturity levels, management practices, and product categories. The analysis relies on one factory and short-term data, so outcomes may differ with factory size, technology maturity and management practices. The study did not include a control group of non-SOP factories, limiting causal attribution and external influences (market shifts, buyer mix, process upgrades) were not fully isolated. Nonetheless, the pattern of results is consistent with the expected impact of disciplined process control in apparel manufacturing and underscores SOPs as a practical lever for operational excellence and buyer trust. Future studies should verify the long-term sustainability of these improvements through extended monitoring beyond the initial post-implementation period. The future scope includes conducting comparative multi-factory studies (with and without SOPs), tracking the long-term effects on efficiency, NPT, HOT, defects, DHU, and on-time shipments, integrating digital SOPs with automation/AI/IoT for real-time control and predictive quality, examining how training, adherence, and employee buy-in influence performance, and evaluating sustainability outcomes such as waste, energy usage, and eco-friendly practices.

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## Biographies

**Md. Tanjid Hossen Irfan** completed his BSc Engineering degree in Industrial and Production Engineering from Khulna University of Engineering & Technology (KUET). His research interests include Optimization, Operations Research, and Supply Chain Management. Currently, he is serving as a Lecturer in the Department of Industrial Engineering and Management at KUET, Khulna, Bangladesh. He has been actively involved in academic teaching, research supervision, and departmental activities. His recent works focus on data-driven decision-making and improving operational efficiency in manufacturing and service industries. He aims to pursue advanced research that integrates analytical modeling with real-world industrial applications.

**Md. Ismail Hossain** is an Industrial & Production Engineering professional currently pursuing his M.Sc. in IPE at Khulna University of Engineering & Technology (KUET), where he also completed his B.Sc. in IPE. He further enriched his academic profile by completing a Post Graduate Diploma in Supply Chain Engineering Management from BIHRM Supply Chain Institute and a PGD in KIM from BRAC University. Professionally, he serves as an Assistant Manager at Super Star Group. Before this role, he worked as a Senior Executive Engineer at Reedisha Knitex Ltd. and as an Executive Engineer at Knit Asia Ltd., gaining extensive experience in planning, industrial engineering, and manufacturing operations. His research interests include supply chain management, sustainability, ergonomics, optimization, and performance improvement in the RMG industry. He has authored more than three research papers in these areas and aims to contribute to innovative, data-driven solutions that enhance efficiency and competitiveness in Bangladesh's manufacturing sector.

**Md. Zaid Hossain** completed his Bachelor of Science in Industrial and Production Engineering from Khulna University of Engineering & Technology (KUET), Bangladesh. He is an emerging industrial engineering professional known for his strong analytical mindset and advanced proficiency in CAD modelling and engineering design. Zaid has contributed as a designer in several academic and practical projects, producing detailed mechanical models, process layouts, and ergonomic design solutions tailored to improve worker comfort, safety, and efficiency. His design outputs reflect both technical precision and a clear understanding of human–machine interaction within industrial settings. Beyond his design capabilities, his interests include operations research, lean manufacturing, supply chain analysis, and the integration of data-centric techniques into production systems. He is particularly driven by challenges related to productivity enhancement, ergonomic improvement, and sustainable manufacturing practices. Combining creativity with engineering judgment, Zaid aims to deliver impactful, real-world solutions that support the evolving needs of Bangladesh's industrial sector.

**Nasif Morshed** is an aspiring postgraduate student currently pursuing a M.Sc. Engineering degree in Industrial Engineering & Management from Khulna University of Engineering and Technology (KUET). His research interests are Supply Chain Optimization, Artificial Intelligence & Machine Learning, Operations Research and Lean Manufacturing, with a focus on their interdisciplinary applications. He has been working on several research topics like Human Digital Twin, IT Capabilities, Sustainability and Environmental Monitoring, Proactive Safety Monitoring, Value Stream Mapping, Circular Economy etc. Also, he has an experience of publishing his previous works on prestigious IEOM Society International, USA and IEEE Xplore.

**Md. Saiful Islam Seam** is a postgraduate student in the Department of Industrial Engineering and Management at Khulna University of Engineering & Technology (KUET), Khulna, Bangladesh. Alongside his academic pursuits, Seam is a multidisciplinary researcher whose work spans Supply Chain Management, Artificial Intelligence, Machine Learning, Operations Research, and Lean Manufacturing. His research interests extend across diverse and impactful domains, including sustainability, environmental monitoring, cellular manufacturing, worker safety, value stream mapping, standard operating procedures (SOPs), and the circular economy. Driven by a commitment to innovation and practical problem-solving, Seam focuses on integrating data-driven methodologies with industrial systems to enhance efficiency, safety, and environmental responsibility.