

# **Developing a Framework to SMED (Single Minute Exchange of Die) Implementation in Garment Section**

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## **Abstract**

The textile and clothing sector remains the backbone of Bangladesh's economy, with the ready-made garment (RMG) industry serving as its dominant export driver. Despite rapid global expansion and sustained competitiveness, RMG production continues to suffer from long changeover times, frequent style variations, and limited standardization—factors that constrain productivity and elevate operational costs. While lean tools such as 5S, Kaizen, and Just-in-Time are widely practiced, the Single-Minute Exchange of Dies (SMED) methodology remains underutilized in apparel manufacturing, despite its proven ability to minimize setup time and improve flexibility. This study develops and validates a structured SMED framework tailored to the dynamic conditions of the RMG industry. The framework integrates lean principles with strategies for handling fabric-specific setups, frequent style changes, and multi-machine operations. Furthermore, it explores the potential of aligning SMED with emerging Industry technologies, including monitoring and real-time analytics. Empirical validation demonstrates that the proposed framework significantly enhances key performance indicators (KPIs) such as setup-time reduction, overall equipment effectiveness, and production responsiveness. The findings highlight how adapting SMED to garments production not only reduces operational inefficiencies but also strengthens global competitiveness, offering a scalable pathway for digital-lean transformation in the RMG sector.

## **Keywords**

SMED, Lean Manufacturing, Apparel Production, Setup Time Reduction, Key Performance Indicators (KPIs), Overall Equipment Effectiveness (OEE), Productivity Improvement, Operational Efficiency.

## **1. Introduction**

The garment sector remains the backbone of Bangladesh's economy, yet its performance is often hindered by lengthy changeover times, frequent style variations, and a lack of standardized processes. These operational challenges restrict productivity and increase overall manufacturing costs. To address these issues, this study proposes a structured methodological framework aimed at improving critical performance parameters. The primary objective is to enhance key performance indicators (KPIs)—including setup-time reduction, overall equipment effectiveness (OEE), efficiency, Standard Minute Value (SMV), and overall productivity—to support more responsive and competitive production systems.

## 1.1 Objectives

- Making a framework for SMED (Single Minute Exchange of Die) implementation.
- Eradicating the limiting factors of overall productivity.
- Calculating the key performance indicators (KPIs) such as setup-time reduction, overall equipment effectiveness, and production responsiveness (Efficiency, Single Minute Value (SMV) and Productivity) of the garment section.

## 2. Literature Review

The apparel sector operates within a dynamic environment characterized by short product life cycles, frequent style changes, and intense global competition. In such a context, rapid production setup and minimal downtime are vital for sustaining competitiveness. The Single-Minute Exchange of Dies (SMED), originally conceptualized in automotive manufacturing, has increasingly been adapted in apparel production as a strategy for streamlining changeovers and enhancing operational responsiveness (Shingo, 1985; Islam, 2013). SMED’s core principle lies in differentiating internal setup activities—tasks that must be performed during machine stoppage—from external setup activities that can be executed while the machine is running. Empirical studies show that converting internal tasks to external tasks significantly reduces machine downtime and enhances operational continuity in apparel sewing lines (Teichgräber & de Bucourt, 2012; Khurana & Talib, 2020). SMED fundamentally distinguishes between internal activities (performed only when machines are idle) and external activities (conducted while operations continue). By systematically shifting tasks from the internal to the external domain, apparel manufacturers can reduce machine stoppages and accelerate style transitions (Ahmed, 2022). Beyond efficiency, SMED also aligns with sustainability objectives. It highlighted its role in minimizing fabric waste and energy consumption, thereby supporting the goals of circular fashion (Kabir, 2021). Case-based investigations provide nuanced insights into these opportunities and challenges. In the textile industry, it reported significant efficiency gains when SMED was combined with Value Stream Mapping and Kanban systems (Marudhamuthu, 2011). More recent contributions have shifted attention toward integrating SMED with advanced technologies and supply chain practices. It revealed that embedding SMED into supply chain resilience frameworks enhanced flexibility, responsiveness, and productivity under volatile demand conditions (Kumar et al. 2024, Bevilacqua et al. ,2024). In addition to productivity gains, SMED contributes to sustainability objectives within the apparel domain. By enabling faster setups and reducing idle operations, SMED has been linked to lower energy use, reductions in fabric waste, and more efficient use of resources—an increasingly important factor for circular fashion systems (Jia et al., 2020; Ni & Li, 2022). Integration with other lean tools further amplifies these benefits. These studies argue that SMED is evolving from a purely operational tool into a strategic capability that enhances flexibility, resilience, and organizational learning across apparel supply chains.

A synthesis of representative works is summarized in Table 1, categorizing findings into operational efficiency, integration with lean tools and supply chain applications. Collectively, these studies illustrate that SMED’s impact extends far beyond setup reduction, encompassing organizational culture, supply chain agility, and digital transformation.

Table 1. Empirical studies regarding SMED implementation

<b>Theme</b>	<b>Representative Studies</b>	<b>Key Findings</b>
Operational Efficiency & Setup Time Reduction	Hashim et al. (2020); Kumar & Patel (2023); Singh & Kumar (2022); Choudhury et al. (2021)	Substantial reduction in setup times, improvement in OEE, throughput gains, and financial savings.
Integration with Lean Tools	Marudhamuthu (2011); Wan. (2022); Sharma & Agrawal (2024)	SMED combined with VSM, 5S, and Lean Six Sigma optimizes workflows and enhances process consistency.
Supply Chain & Industry 4.0 Applications	Kumar et al. (2024); Bevilacqua et al. (2024); Zhang et al. (2024); Mehta & Jain (2023)	SMED integration with supply chain resilience and digital technologies improves agility and lead-time performance.

### 3. Methodology

This study was conducted in collaboration with a knit composite garment manufacturing company in Bangladesh. The study includes action research methodology and consists of 5 phases, as follows: 1<sup>st</sup> – Analyzing strategies for SMED implementation, 2<sup>nd</sup> – Gathering knowledge from various papers and experts feedback, 3<sup>rd</sup> – Identification of appropriate strategies, 4<sup>th</sup> – Validation of strategies through expert’s feedback, 5<sup>th</sup> – Implementation of the validated strategies.

#### 3.1 Analyzing strategies for SMED implementation

This step involves reviewing the goals of SMED implementation, understanding the need for reducing changeover time, and exploring different methods that can be applied. It sets the stage for strategy selection by analyzing the current situation and understanding where improvements can be made. The primary goal of the study is to design a standardized SMED implementation model tailored to the garment manufacturing sector. The research integrates both qualitative and quantitative approaches. Qualitative insights are obtained through expert consultations and operator interviews, while quantitative inputs are derived from time–motion studies, setup-time data collection, and efficiency measurements.

#### 3.2 Gathering knowledge from various papers and expert’s feedback

Academic research and case studies are reviewed to gather insights on successful SMED implementations in different industries. This provides a theoretical foundation and examples of best practices to identify suitable strategies for implementation. Consulting with industry experts or professionals experienced in SMED implementation helps to validate the knowledge gathered from papers. Experts provide practical advice and suggestions based on real-world applications, helping refine the strategies being considered.

#### 3.3 Identification of appropriate strategies

After knowledge gathering and expert consultation, specific strategies that are most relevant and suitable for the company or process in question are identified. These strategies are chosen based on their applicability to the existing processes and potential to reduce changeover time (Table 2).

Table 2. The problems, strategies & implications in the pre-production stage

<b>Problem</b>	<b>Strategy</b>	<b>Implication</b>
Variation in styles	Style standardization	Production aligned to planned styles
Frequent plan changes	Adherence to planning	Strict alignment with approved plan
Inventory delays	Early inventory placement	Raw materials and trims in-housed prior to production
Plan variation	Production scheduling	Compliance with planning department schedule
Incorrect sample development	Approval control	Ensure pre-production sample approvals
Inadequate machine maintenance	Preventive maintenance	Weekly scheduled maintenance
Lack of training	Worker training	Monthly training sessions

The pre-production stage exhibited a set of challenges that directly impact efficiency and process stability. Table 3 summarizes the problems and corresponding strategies. Issues such as variation in styles and plan variation were mitigated through style standardization and production scheduling, aligning production more closely with the planning department’s targets. Similarly, inventory delays were addressed by early inventory placement, ensuring timely in-housing of raw materials and trims. Frequent plan changes were controlled through adherence to production planning, which enforces strict compliance with approved schedules. Quality-related problems, such as

incorrect sample development, were minimized through approval control, ensuring that pre-production samples met buyer requirements. Finally, machine- and skill-related issues such as inadequate maintenance and lack of training were addressed via preventive maintenance (weekly schedules) and worker development programs (monthly training).

Table 3. The problems, strategies & implications in the production stage

<b>Problem</b>	<b>Strategy</b>	<b>Implementation</b>
Reduced flexibility in production	Modular sewing lines	Reduced setup time across styles
High downtime during style changes	Pre-style machine setup	Setup completed during pre-production
Precision and quality losses	Controlled setup changes	Critical setups minimized and planned
Late material arrival	Pre-arranged material kits	Cut fabrics and trims prepared in advance
Shade variation	Color-coded process	Systematic panel-based sewing
Post-production quality issues	Traffic light inspection system	In-line quality monitoring

During the production stage, several bottlenecks were observed. Reduced flexibility and downtime during style changes were addressed through modular sewing lines and pre-style machine setups, both of which helped reduce setup time across styles. To ensure precision and quality, controlled setup changes were introduced, limiting critical adjustments to planned interventions. Material-related delays were mitigated by pre-arranged material kits, ensuring that cut fabrics and trims were available prior to production. Color consistency was improved using a color-coded sewing process, which systematized panel alignment and reduced shade variation. Finally, traffic light inspection systems were implemented as an in-line quality monitoring tool, reducing post-production rework and ensuring proactive detection of quality deviations.

### **3.4 Validation of the strategies through expert’s feedback**

Before implementing the strategies, they are validated by obtaining feedback from experts or stakeholders. This step ensures that the strategies are feasible and effective. Suggested modifications and adjustments are used to improve their implementation potential. For validation process, a QFD (Quality Function Deployment) model was developed. This QFD model helped to determine the key strategies to be implemented. Below Fig 1. Implies how different customer needs in a garment production environment are connected to key technical factors such as efficiency, productivity, SMV, and setup time. The project focuses on applying SMED in the garment section, and the chart helps identify which areas should be improved first.

On the left side, customer requirements—like modular sewing lines, pre-style machine setup, controlled critical operations, pre-arranged material kits, traffic light inspection systems, and worker training—are listed with their importance ratings. These ratings reflect how strongly each requirement matters to customers or production goals.

Across the top, the functional requirements (OEE, efficiency, productivity, SMV, and setup time) show the technical aspects that influence those customer needs. The numbers inside the matrix (1, 3, and 9) represent how strong the relationship is between each customer’s needs and each technical factor. Higher numbers show a stronger impact. Each row’s weighted score is calculated based on how important the customer requirement is and how strongly it connects to the technical factors. This helps identify which improvements will give the biggest overall benefit. Items like modular sewing lines, pre-style machine setup, and controlled critical operations receive higher scores, meaning they should be prioritized. At the bottom, the table summarizes which technical areas carry the most weight. Setup time and productivity show the highest technical importance percentages, indicating these areas will deliver the most

improvement if optimized. Finally, the priority ranking gives a clear direction on which technical requirements should be addressed first, with setup time ranking at the top (Figure 1).

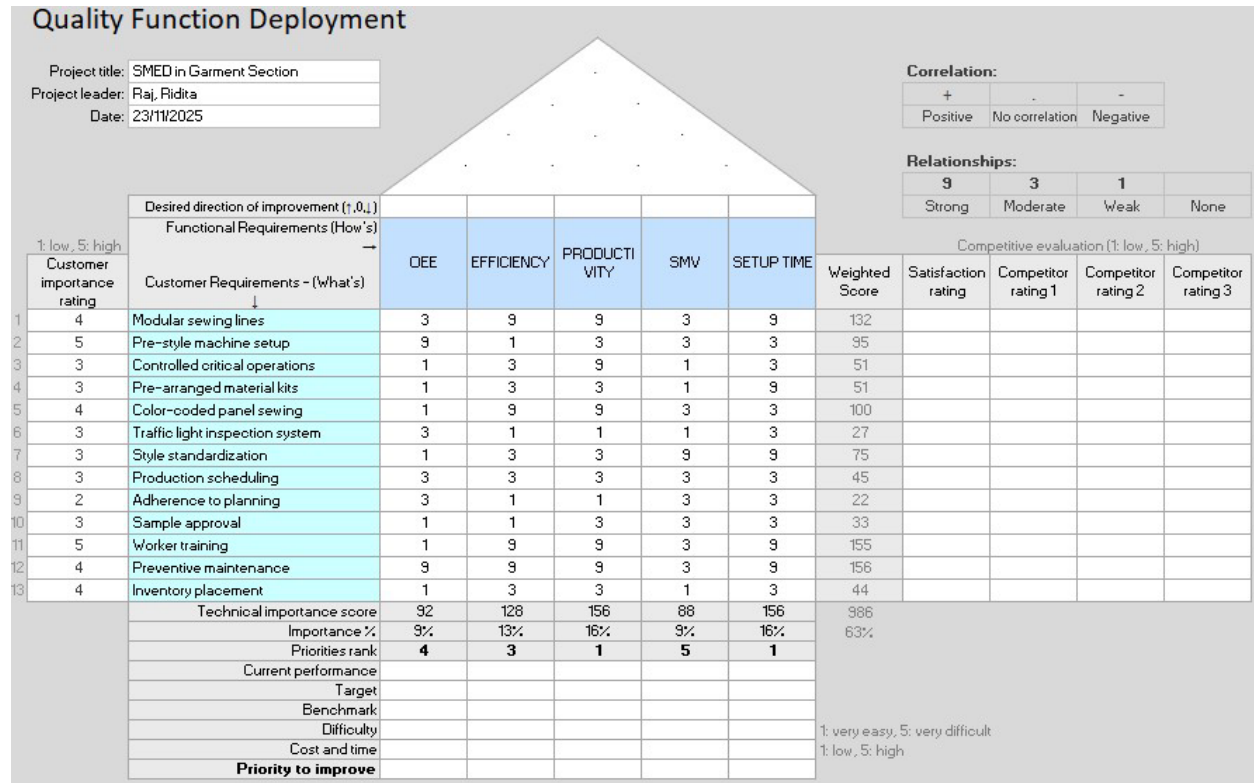


Figure 1. QFD (Quality Function Deployment) Modeling Diagram

### 3.5 Implementation of the validated strategies

Once validated, the strategies are put into action. This involves reorganizing and adapting processes based on the SMED principles. The focus here is on making systematic improvements that reduce changeover time. After implementation, the new changeover time is measured. This step is crucial to assess the effectiveness of the strategies. The difference between the old and new changeover times is used to evaluate the success of the SMED implementation. This decision point checks if the implemented strategies have led to a reduction in changeover time. If the answer is yes, the process moves forward. If not, a reevaluation of the strategies is needed, and further adjustments or new strategies might be implemented. This can be easily shown below (Figure 2.) in a step-by-step process diagram.

The model shown in the flowchart (Figure 2.) explains a step-by-step approach for applying SMED strategies in a before and after production environment. It begins with analyzing different strategies that could support SMED implementation. For doing this, two main sources are used: published research papers and insights from industry experts. These two inputs help build a strong understanding of what methods might work best.

After gathering this information, the next step is to identify which strategies are suitable for the specific production process being studied. Once the potential strategies are listed, the model requires identifying the challenges that could make these strategies difficult to apply. This ensures that any obstacles are recognized early.

The selected strategies are then validated through expert feedback. This validation step is important because it confirms whether the strategies are realistic, relevant, and practical. After receiving expert confirmation, the validated strategies are validated by QFD modeling diagram and implemented in the actual production environment.

Once the implementation is done, the changeover time is recalculated to see if there is any improvement. The main goal of SMED is to reduce changeover time, so this measurement is essential. If the changeover time is not reduced, the process loops back, requiring re-evaluation and adjustments.

If the new changeover time shows improvement, the model then checks whether the overall approach is valid. This ensures that the results are not accidental but truly based on the effectiveness of the strategies. If the model is considered valid, the final step is to provide meaningful implications, including limitations and recommendations for future research. Overall, the model provides a clear and logical framework for selecting, validating, and evaluating SMED strategies in a structured way.

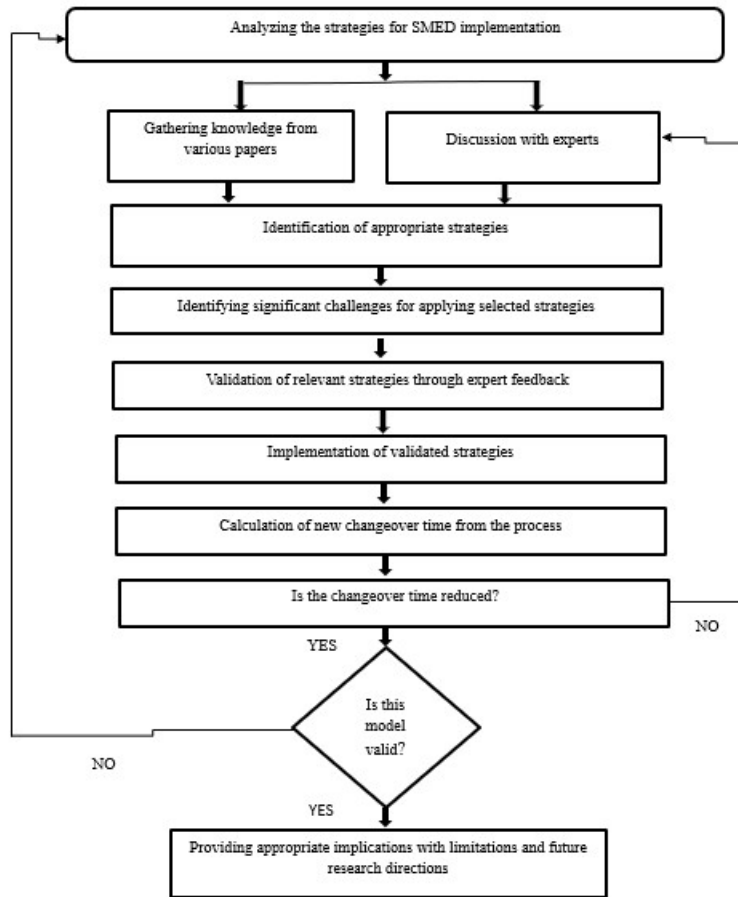


Figure 2. SMED Implementation Framework

#### 4. Results

After implementation of the validated strategies, results were obtained. The before and after setup times show the time saved in this process. The below Table 4. compares setup activities before and after an improvement effort, showing how each stage became more streamlined. It lists areas of machine preparation, arranging attachments, managing resources, adjusting power, organizing manpower, and making technical adjustments. For each task, this Table 4. displays the original duration, the reduced duration, and the difference achieved. It highlights how every component of the setup process benefited from the changes, with noticeable cuts across all categories. The final row sums up the total time used before and after, emphasizing the overall efficiency gain and offering a clear picture of how workflow enhancements paid off.

Table 4. Results obtained after SMED Implementation

Setup time of components	Before time (Min)	After time (Min)	Time saved (Min)
Machine setup time	210	175	35
Attachment arrangement time	55	40	15
Resource management time	185	160	25
Power adjustment time	75	50	25
Manpower arrangement time	99	79	20
Technical adjustment time	100	86	14
Total time	724	590	134

The below (Figure 3.) chart gives a clear side-by-side look at how much time each part of the setup process took before and after improvements were made. Each group of bars represents one component of the setup, such as machine setup, attachment arrangement, or manpower arrangement. By placing the “before,” “after,” and “time saved” values together, the graph makes it easy to see where the biggest reductions happened.

From the visual pattern, it’s obvious that machine setup time was the most time-consuming area at first. It also shows a noticeable drop after improvements, saving 35 minutes. Resource management and power adjustment show the same trend—both started as time-heavy tasks but showed significant reductions afterward. Smaller tasks like

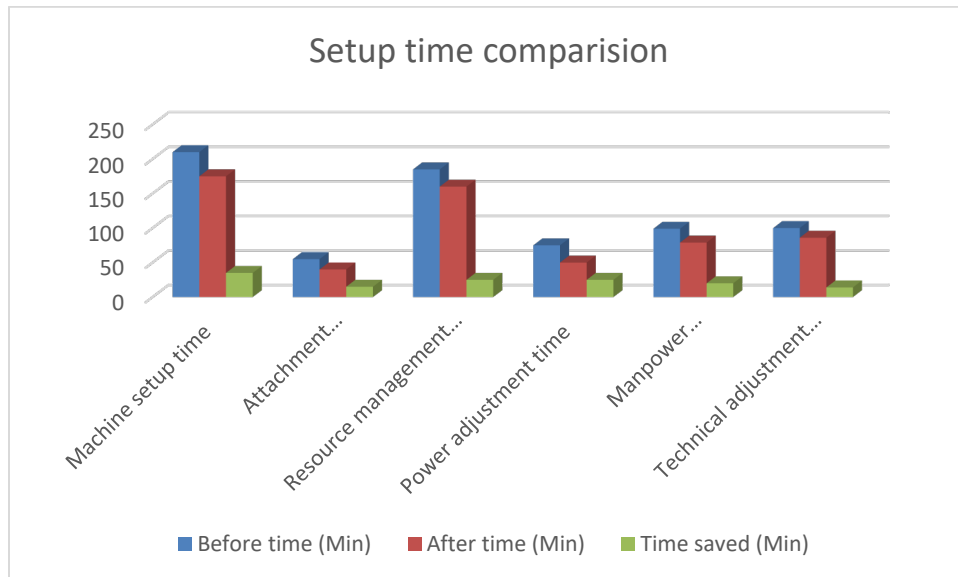


Figure 3. Setup time comparison graph

attachment arrangement and technical adjustment also improved, though their overall time savings were lower simply because they required less time from the beginning.

What stands out most is the consistency across all components: every part of the setup process shows some level of improvement. While some sections show bigger drops than others, the graph makes it clear that the changes had a positive effect across the board. The total reduction of 134 minutes becomes visually believable when you look at how each bar set shrinks from the ‘before’ to the ‘after’ category. Overall, the chart is effective because it visualizes improvement without requiring complicated analysis. It can be implied immediately where the most time was saved and how evenly the improvements are distributed through the different set-up components.

## 5. Conclusion

We can conclude that the methodological approach fulfills the goals of the research. The working principle of the strategies identification, validation through QFD model & using the process flow is continuous development

process. Moreover, the research implies ease of strategies selection according to the need. From an economic perspective, SMED helps companies operate more cost-effectively by reducing waste, both in terms of materials and time. Though the model is easy to implement but it still has some limitations. However, implementing SMED in the garment industry has some challenges, such as the need for detailed analysis and re-engineering of current processes to ensure quick changeovers. Training workers to handle SMED implementation techniques and making necessary investments in technology and equipment upgrades are also critical to its success.

## **6. Future work**

Future work on SMED implementation in the garment sector can focus on expanding digital integration, such as using real-time data tracking & storing to reduce setup delays. Research can explore advanced machine layouts to minimize operator movement and improve tool accessibility. Another direction is developing standardized monthly training modules to reinforce quick-change habits. Studies can also examine the impact of automation, like modular machines or smart attachments for machines, on setup efficiency. Finally, future work may compare SMED results between factories to identify common barriers and create industry-wide improvement frameworks.

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**Riaz Uddin Raj** graduated from the Department of Industrial and Production Engineering at the Bangladesh University of Textiles, Dhaka, Bangladesh. Alongside his academic work, he has developed strong interests in operations research, lean manufacturing, sustainability, AI & simulation engineering and supply chain management. He has actively participated in a range of co-curricular activities throughout his college and university years, reflecting his commitment to personal and professional growth. Passionate about acquiring new skills and embracing complex challenges, he aspires to advance his research career by pursuing higher studies in the near future.

**Jannate Nur Ridita Alam Aanchal** graduated from the Department of Industrial and Production Engineering at the Bangladesh University of Textiles, Dhaka, Bangladesh. Alongside her academic pursuits, she has cultivated a strong interest in research, particularly in operations research, supply chain management, Industry 4.0, artificial intelligence, and data science. Throughout her school, college, and university years, she has been deeply involved in a variety of co-curricular activities, demonstrating her enthusiasm for continuous learning and personal development. She aims to pursue higher studies in the future, with a strong focus on advancing her research career.