Productivity Improvement in Textile Industry with Lean Manufacturing Practices of 5S and PDCA: a case study

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*ABSTRACT: In the rapidly growing textile and garment industry, achieving higher productivity while maintaining quality standards is critical to global competitiveness. This study examines the application of Lean Manufacturing principles at TNG Investment and Trading Joint Stock Company, a leading enterprise in the Vietnamese garment industry, to improve labor productivity and operational efficiency. The study uses secondary data collection and analytical methods, including Pareto chart analysis and cause-and-effect diagrams, to identify and resolve common problems such as broken stitches and open seams, major defects affecting production quality. The findings confirm that Lean Manufacturing tools significantly reduced waste, increased labor productivity, and improved product quality at TNG. These results demonstrate the transformational potential of Lean Manufacturing as a strategic approach to achieving sustainable growth in the textile and apparel industry. The study also provides actionable recommendations to optimize Lean implementation further, ensuring long-term success in an increasingly competitive global market.*

***KEY WORDS: Lean manufacturing, 5S, PDCA, Pareto analysis, Operational efficiency, Overall equipment effectiveness***

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# INTRODUCTION

The textile and garment industry is a cornerstone of Vietnam’s industrialization and modernization efforts. As one of the nation’s primary manufacturing sectors, it holds tremendous potential for development and contributes significantly to economic growth. Within this context, Lean Manufacturing (LM) received considerable attention from manufacturing companies as a highly effective management approach to optimize production processes. Its implementation eliminates waste, reduces cycle time, and improves overall productivity, especially in the labor-intensive garment industry.

This paper examines a case study of TNG Investment and Trading Joint Stock Company, a leading enterprise in Vietnam’s garment sector, which has successfully adopted LM techniques to achieve remarkable productivity improvements. By systematically employing Lean principles, TNG has optimized workflows, minimized waste, and strengthened its competitiveness in both domestic and international markets. The study focuses on assessing the efficacy of LM tools, specifically 5S and PDCA, as well as evaluating Overall Equipment Effectiveness (OEE) before and after applying such LM tools at TNG. Its objective is to provide a comprehensive understanding of how Lean Manufacturing contributes to TNG’s operational success. Moreover, the case study serves as a model for other enterprises seeking to modernize operations, enhance efficiency, and adapt to the dynamic demands of a globally integrated economy. Thus, through the achieved results, the study not only provides valuable insights into the practical effectiveness of LM methodology but also offers strategic recommendations to further enhance TNG’s productivity and sustain its competitive edge in the global textile and garment industry.

***1.1. Lean Manufacturing***

The ultimate goal of any manufacturing enterprise is to achieve customer satisfaction by consistently delivering high-quality products in a timely manner and at a competitive cost. Key factors influencing product costs, such as equipment, materials, and labor, tend to increase because of inflation, making their effective utilization paramount. Underutilization of these resources leads directly to operational inefficiencies and financial losses. Therefore, organizations must maximize resource utilization, minimize waste across production activities, and adopt innovative working methods and techniques [[1](#_ENREF_1)]. LM is considered a powerful approach to achieving high efficiency and sustaining business growth [[2](#_ENREF_2)].

According to Camacho-Miñano et al. [[3](#_ENREF_3)], LM has been considered as a holistic business strategy and has gained prominence as a vital methodology across various manufacturing sectors, including automotive, electronics, plastics, textiles, food processing, dairy production, and foundries. At its core, Lean production focuses on getting rid of waste and fostering continuously improvement by reducing inventory, excess capacity, and other non-value-added activities [[2](#_ENREF_2)]. By adopting Lean techniques, organizations can achieve significant benefits, such as shorter cycle times, elimination of redundant activities and streamlined production flow. Such advancements would increase productivity and reduce production costs, leading to better overall production efficiency for the organization.

The core objective of LM, as both a methodology and operational philosophy, is to maximize productivity while minimizing waste, variability, and inefficiency across manufacturing systems and processes. In Lean, waste is defined as anything that does not add value from the customer's perspective- activities or resources that customers are unwilling to pay for. LM systematically achieves the shortest cycle time by eliminating waste in the production processes, continuously upgrading systems and only consisting of value-added steps from start to finish. As a result, manufacturers have highly efficient operations, increasing competitiveness in the market [[4](#_ENREF_4)]. Deshmukh et al. [[5](#_ENREF_5)] believed that reducing waste and focusing on value-added activities within LM enables organizations to maximize the utilization of their resources.

Furthermore, Lean is not just about cutting waste, it is about creating systems that consistently deliver value in the most efficient and effective manner. LM helps to get a clean, organized, and hygienic workplace by enhancing communication and internal connectivity for faster decision-making and more agile responses to market demands. Adopting Lean principles has enabled companies to achieve remarkable operational improvements, including doubling worker productivity, reducing inventory by up to 90%, and cutting customer defects by as much as 50% [[6](#_ENREF_6)]. These advancements boost product quality and lead to heightened customer satisfaction and competitiveness in the marketplace [[7](#_ENREF_7)].

***1.2. 5S methodology***

The 5S method is the key pillar of the LM system [[8](#_ENREF_8)]. Originating from Japanese practices, 5S aims to eliminate unnecessary items, arrange essential items efficiently, maintain clean and organized spaces, standardize processes, and ensure long-term sustainability [[9](#_ENREF_9)]. More than just a tool for cleaning, sorting, organizing, and functioning, the method also optimizes processes, improves productivity and quality by eliminating idle time and non-value-added operations in the production process, and encourages employees to participate in continuously improving their work environment [[10](#_ENREF_10)]. It is important to note that 5S is an industrial practice that can distinguish a company from its competitors. By adopting the 5S methodology, enterprises can create a safe and healthy workplace, ensure compliance with standards, and promote quality improvement [[11](#_ENREF_11)].

In recent years, as mentioned by Hamja et al. [[12](#_ENREF_12)], the textile and apparel industry has begun adopting LM with 5S as an early step. The close relationship between Lean Manufacturing and the 5S method underscores its importance as the initial phase of Lean implementation. By laying the foundation for continuous improvement and enhancing production efficiency, 5S sets the stage for the successful application of Lean principles. 5S consists of five phases as shown in Figure 1.

* Seiri (整理) - Sorting: Classifying and filtering items in the work area to remove unnecessary objects. Unused items must be removed, reused or liquidated. To enlarge production process’s effectiveness and efficiency, only essential items are kept to ensure a more effective and streamlined production process [[13](#_ENREF_13)]
* Seiton (整頓) - Set in Order: After sorting, the next step is arranging items scientifically and concisely according to the principle: Easy to find, Easy to see, Easy to take and returned to its original place after use. Items must be placed in the correct location to enhance safety, quality as well as efficiency for the manufacturing activity [[14](#_ENREF_14)]
* Step 3. Seiso (清掃) - Shine: To keep the workspace neat, tidy and in the correct location of items. Indiscipline, faulty production, and working accidents might be caused by dust and dirt. Therefore, each employee needs to be aware of maintaining hygiene and cleaning the workplace after each shift [[15](#_ENREF_15)]; [[16](#_ENREF_16)].
* Seiketsu (清潔) - Standardize: Standardization in the workplace plays a crucial role in sustaining the three previous S. It involves establishing clear guidelines to ensure consistency in daily operations as a routine in businesses [[15](#_ENREF_15)].
* 5. Shitsuke (躾) – Sustain: Maintain is to build the habit of voluntarily maintaining 5S activities to create a high-quality and comfortable working environment. A well-maintained 5S system reduces operational costs while enhancing overall efficiency [[17](#_ENREF_17)].

|  |  |
| --- | --- |
| One effective Lean manufacturing tool is “5S.” |  |
| ***Figure 1. 5S Steps Process*** | ***Figure 2. PDCA Cycle*** |

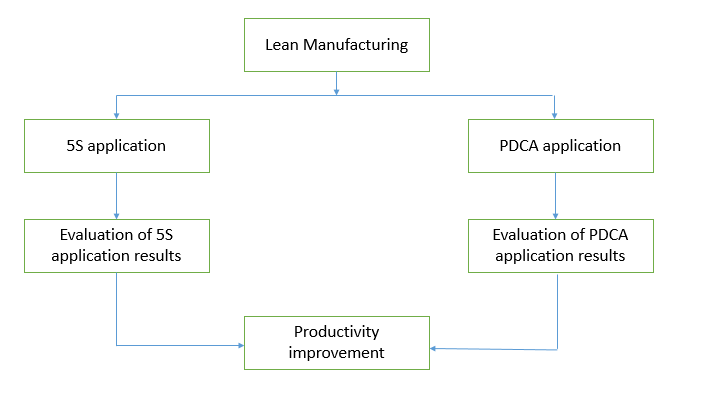
***1.3. PDCA Methodology***

The PDCA cycle is an interactive problem-solving strategy aimed at enhancing processes and implementing improvements. In 1950, Edwards Deming, an expert in the field of quality management, introduced the concept of “continuous improvement” for manufacturing companies, referring to it as the Deming wheel. It emphasized constant interaction among *Design-Production-Sale-Research* [[18](#_ENREF_18)]. After that, to highlight the central principle of quality improvement, Japanese practitioners modified the wheel into the Plan-Do-Check-Act (PDCA) cycle [[19](#_ENREF_19)], as presented in Figure 2. PDCA cycle’s principle is flexible, reasonable and more future-oriented.

Accroding to Jagtap [[20](#_ENREF_20)], the PDCA cycle consists of repeating four steps, starting with a clear plan and defining the implementation steps (Plan). Then, the plan is carefully implemented and followed (Do). Next, the implementation results are assessed against the original goals to evaluate the effectiveness (Check). Finally, based on the test results, the last step is to address the errors, learn from the experience, solve problems and apply it to the next cycle (Act). Instead of a one-time process, PDCA operates as an ongoing process to reach the goals in the planning step [[21](#_ENREF_21)].

PDCA is widely applied in the manufacturing sector, particularly in reducing defect rates and minimizing operational inefficiencies [[22](#_ENREF_22)]. Additionally, this cycle can also deliver a variety of benefits for the company, including enhancing quality management, minimizing idle time and energy consumption [[23](#_ENREF_23)], reducing warranty-related costs, extending product prestige and customer satisfaction [[20](#_ENREF_20)].

# METHODOLOGY



***Figure 3. Research model***

This research employs a quantitative approach using secondary data to evaluate the effectiveness of LM, specifically focusing on the tools 5S and PDCA, within the TNG company, Vietnam. The data, relating to sewing line’s production cycle time, product defect rates, and machine downtime, was sourced from annual internal production reports. By analyzing Pareto charts and OEE, this paper emphasizes a comparative analysis of production processes before and after the implementation of LM practices. The following steps outline the systematic approach undertaken in this research.

***Step 1: Determine the theme with Pareto charts***

Firstly, the secondary data was gathered from internal production reports. To assess the impact of LM, data were randomly collected over two distinct periods: five randomly selected days prior to the implementation of Lean practices and five randomly selected days after implementation. This approach ensures a comparative analysis of key production indicators before and after Lean application. After that, Pareto diagrams were carried out to prioritize the most important factors affecting productivity at TNG. Pareto charts are a useful tool in LM to prioritize important issues, following the 80/20 principle [[24](#_ENREF_24)].

***Step 2: Determine the operational performance with OEE***

The operation performance of one firm is often measured by the OEE. OEE is a core metric for determining the efficiency of all equipments in the manufacturing system compared to their maximum capacity [[25](#_ENREF_25)]. This metric is widely considered an essential tool for the measurement of productivity and is often used in LM strategy to improve efficiency and reduce waste [[26](#_ENREF_26)]. According to Nakajima [[27](#_ENREF_27)], the founder of the OEE concept in Total Productive Maintenance TPM, and Dal et al. [[28](#_ENREF_28)], this indicator is calculated as the formula below:

|  |  |
| --- | --- |
| *OEE= Machine Availability× Performance Efficience × Rate of Quality* | **(1)** |

which

* *Machine Availability*: Evaluates the ratio of the time that equipment is ready to operate compared to the planned time, which relates to the flexibility of processes. The standard rate should be at least 90% [[29](#_ENREF_29)]
* *Performance Efficience*: Measures the actual production rate compared to the optimal design rate of the equipment. The standard rate should be at least 95% [[29](#_ENREF_29)]
* *Rate of Quality*: Determines the ratio of qualified products to the total number of products produced. The standard of the *Rate of Quality* should be at least 99% [[29](#_ENREF_29)]

Ylipää et al. [[30](#_ENREF_30)] conducted that the average OEE has been identified as around 50% as generally realistic in enterprises. According to Petrillo et al. [[31](#_ENREF_31)], manufacturers achieving an OEE of at least 85% are considered high competitiveness advantage. Therefore, increasing OEE level has become an objective of every company in attaining a tremendous competitive advantage. Many studies confirm the implementation of 5S and PDCA to reduce waste, increase OEE and improve business performance in different countries and industries, eg, in highway engineering industry [[32](#_ENREF_32)], plastic industry [[33](#_ENREF_33)], manufacturing industry [[34](#_ENREF_34)], agriculture industry [[35](#_ENREF_35)], garment industry [[36](#_ENREF_36)].

***Step 3: Measure Productivity/ Improvement Growth***

Next, Improvement growth for each indicator was calculated by the ratio between difference before and after improvement, shown as the formula (2)

|  |  |
| --- | --- |
| *Improvement Growth =* | **(2)** |

This structured approach ensures a thorough assessment of LM’s impact, providing valuable insights into how the methodology enhances productivity and operational efficiency at TNG Company.

# RESULTS AND DISCUSSIONS

The data collection process was conducted at TNG Investment and Trading Joint Stock Company, focusing on a specific sewing line. The investigation highlighted significant issues within the sewing line, prompting an in-depth analysis of their root causes. Initially, only one quality check was included in the production process before final product packaging. After a detailed review of the collected data, the company considered implementing an additional quality check, subject to a significant reduction in the defect rate in the sewing process. The production flow and a summary of data collection for the sewing line are presented below.

|  |  |
| --- | --- |
|  |  |
| 1. ***Sewing line before Lean*** | 1. ***Sewing line after Lean*** |

***Figure 4. Sewing line model at TNG before and after implementing LM***

The model outlined in Figure 4 illustrates the enhancements to the production process within the sewing line, developed as a result of a comprehensive analysis of the issues observed in model 2a. The primary goal of the revised process is to improve overall efficiency while minimizing defects in the final product. A significant change introduced in this model is the inclusion of an extra inspection stage strategically placed into the workflow. This added quality control checkpoint is designed to identify potential defects earlier in the production cycle, preventing these issues from reaching the later stages. By addressing problems sooner, the new inspection point helps to significantly reduce the defect rates, thereby ensuring higher quality outputs and preventing defects from escalating further down the production line. This modification, combined with other process optimizations, is expected to result in more consistent product quality, fewer rework efforts, and enhanced overall production efficiency.

***Table 1. Comparative Analysis of Defect Reduction Before and After LM Implementation***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Name of Defects** | **Day 1** | **Day 2** | **Day 3** | **Day 4** | **Day 5** | **Total  Defects Per Item** | **Percentage of Defects** |
| **Before Lean** | Broken stitch | 45 | 25 | 17 | 20 | 24 | 131 | 28.0% |
| Open seam | 21 | 29 | 4 | 23 | 19 | 96 | 20.5% |
| Sewing reject | 4 | 15 | 3 | 17 | 21 | 60 | 12.8% |
| Raw edge | 11 | 0 | 16 | 16 | 14 | 57 | 12.2% |
| Joint stitch | 7 | 2 | 8 | 3 | 15 | 35 | 7.5% |
| Uncut thread | 8 | 3 | 6 | 6 | 5 | 28 | 6.0% |
| Other defects | 1 | 0 | 8 | 14 | 1 | 24 | 5.1% |
| Skip stitch | 3 | 0 | 8 | 0 | 7 | 18 | 3.8% |
| Fabric fault | 6 | 1 | 0 | 3 | 2 | 12 | 2.6% |
| Needle damage | 1 | 0 | 0 | 4 | 2 | 7 | 1.5% |
| **Total defects per day** | **107** | **75** | **70** | **106** | **110** | **468** | **100.0%** |
| **After Lean** | Broken stitch | 21 | 7 | 12 | 10 | 5 | 55 | 25.8% |
| Open seam | 8 | 7 | 8 | 9 | 7 | 39 | 18.3% |
| Sewing reject | 3 | 5 | 10 | 6 | 5 | 29 | 13.6% |
| Raw edge | 3 | 0 | 3 | 7 | 8 | 21 | 9.9% |
| Joint stitch | 5 | 2 | 4 | 3 | 0 | 14 | 6.6% |
| Skip stitch | 2 | 0 | 3 | 5 | 4 | 14 | 6.6% |
| Fabric fault | 2 | 2 | 6 | 1 | 2 | 13 | 6.1% |
| Uncut thread | 4 | 1 | 2 | 0 | 5 | 12 | 5.6% |
| Other defects | 1 | 0 | 4 | 5 | 0 | 10 | 4.7% |
| Needle damage | 1 | 0 | 1 | 3 | 1 | 6 | 2.8% |
| **Total defects per day** | **50** | **24** | **53** | **49** | **37** | **213** | **100.0%** |

According to the data above, several critical issues and gaps in the production plan have been identified. Before applying LM tools, one of the most pressing challenges was the limited quality control (QC) system. The production process consists of a single QC checkpoint located just before the packaging stage. As a result, products with a significant defect rate are immediately rejected without an opportunity for rework, leading to an elevated rejection rate and substantial financial losses. On the other hand, items with minor defects are rerouted back to Machine 1 for rework, which is inefficient and time-consuming, ultimately slowing down the entire production flow. These inefficiencies increase delays and waste valuable resources, thereby highlighting the necessity for comprehensive process optimization.

***Figure 5. Pareto analysis of defects in the production process before Lean***

As illustrated by the Pareto chart in Figure 5, broken stitches emerge as the most important flaw, making up 28.0% of all reported issues and representing the primary cause of production challenges. The issue of open seams, which accounts for 20.5% of the defects, comes next. Together, they make up the Vital Few, the main problem areas that need to be addressed right away in order to enhance overall quality. In addition to these major concerns, other notable flaws include joint stitches (12.8%), sewing rejects (12.8%) and raw edges (12.2%). Meanwhile, the remaining 19% comprises a variety of minor flaws that together cover a wide range of less common but significant problems. This highlights the urgent need for implementing additional QC checkpoints throughout the production stages to mitigate defect rates more effectively.

To overcome these operational obstacles, the 5S methodology to these idle and bottleneck stations was suggested to apply to increase organization, minimize waste, and streamline workflow, ultimately boosting the overall production efficiency. As a structured system, 5S aims to foster productivity, quality, efficiency, and safety by optimizing the work environment and reducing waste and unnecessary activities. The 5S’s core philosophy prioritizes standardized work routines and effective workplace management, in tandem with the PDCA framework to drive continuous improvement. Since both 5S and PDCA significantly influence daily workplace functions, their integration is essential to perform tasks efficiently and effectively. Adopting these methodologies represents the most effective strategies for successfully implementing LM, nurturing sustained progress and operational excellence.

The data presented in Table 1 also shows the defect rate of the sewing line following the implementation of LM techniques, including an extra quality inspection stage. As seen in the second section of Table 1, after adopting Lean, broken stitches remain the most frequent defect, accounting for 25.8% of the total. Open seams rank as the second most common issue, constituting 18.3%. Also, sewing rejects are 13.6%, Raw edges are 9.9%, Joint stitches make up 6.6%, while various other minor defects collectively represent 25.8% of the total. The data analysis revealed that broken stitches and open seams remain the Vital Few, the primary defects requiring immediate attention, as illustrated in Figure 7 below.

***Figure 6. Pareto analysis of defects in the production process after Lean***

The graph in Figure 7 provides a comparison of defect rates before and after employing Lean tools. Significant improvements can be seen in the top major defects, including broken stitches, open seams, raw edges, and graft stitches, all of which demonstrated a measurable reduction in frequency after the intervention. These positive outcomes can be attributed to the reduction in downtime (loss time in the production process), improvement in product quality, as well as establishment a clean and organized workspace (which includes tasks such as sweeping floors and cleaning machinery). Clearly, the TNG company not only ensures processes run smoothly but also enhances product quality.

However, the comparison of sewing defects also reveals an increase in the rejection rate under the updated model. This rise in the rejection rate can be attributed to the introduction of an additional quality inspection step in the production line. Although this step enhances defect detection, it initially disrupts production flow, resulting in higher rejection rates and a temporary negative impact on OEE results.

***Figure 7. Comparison of Defect rates before and after 5S and PDCA implementation***

As analyzed above, the adjustments made in the updated model have helped optimize the production process, reduce waste and downtime, and improve equipment utilization. However, these modifications have also introduced certain negative impacts on OEE. This section will provide a detailed analysis of the OEE results to thoroughly assess the effects of the adjustments in TNG’s production process. When comparing the initial and proposed models, both rely on data from the company’s sewing line. The indicators reveal no overlap, as a result, utilizing historical process data allows the system to maintain a consistent production flow on the sewing line across all scenarios. Table 2 illustrates a substantial difference between the improved model and the previous model, further reinforcing the effectiveness of the applied LM methodologies.

***Table 2. Parametric indicators comparison.***

|  |  |  |  |
| --- | --- | --- | --- |
| Parametric Indicator | Before using Lean | After using Lean | Improvement growth |
| Downtime of one shift | 12% | 8% | - |
| Idle run rate | 5 pieces/minute | 5 pieces/minute | - |
| Processed amount (avg.) | 1880 units | 1838 units | - |
| Reject product (avg.) | 106 units | 37 units | - |
| Machine Availability (A) | ***86%*** | ***91%*** | ***5.82%*** |
| Performance Efficiency (P) | ***90%*** | ***84%*** | ***(6.67%)*** |
| Rate of Quality (Q) | ***94%*** | ***98%*** | ***4.26%*** |
| **OEE = (A) x (P) x (Q)** | **72.76%** | **74.91%** | **2.96%** |

Based on internal reports from TNG, downtime (including both scheduled and unscheduled interruptions) initially accounted for 12% of the shift. This inefficiency was due to a variety of factors, such as irregular machine maintenance, material shortages, quality issues, operator errors, utility disruptions, and unsafe working conditions. These challenges were systematically addressed through the implementation of the LM methodology, resulting in a significant reduction in downtime. Following the application of 5S and the PDCA cycle, production flow downtime reduced to 8% per shift, leading to an increase in operating time and subsequently, an improvement in *Machine Availability* – one of the three key components of OEE. As presented in Table 2, Machine Availability rose from 86% before LM implementation to 91% afterward.

Furthermore, an additional QC stage in the updated model (Figure 4b) helps identify defects earlier in the production cycle, ensuring higher product quality and reducing waste. Prior to LM adoption, the average production volume was 1,880 units per shift, with approximately 106 units rejected due to defects. Even though the advanced model aimed to increase production rates by minimizing downtime, the average output after employing LM decreased to 1838 units per shift, as indicated in Table 2. The reason is that achieving higher production efficiency was hampered by the additional quality checks introduced into the sewing line and the subsequent rework required for defective items. In other words, while the advanced model improves the ability to detect defects and enhances overall quality, an increase in sewing rejections has led to a lower per-shift production volume and extended cycle times. However, the number of defective units per shift dropped significantly to just 37, resulting in a notable improvement in product quality. Consequently, the Rate of Quality rose from 94% to 98% while the Performance Efficiency declined from 90% initially to 84% after the application of 5S and PDCA.

According to Table 2, OEE improved by 2.15%, rising from 72.76% to 74.91% and its Improvement growth was 2.96%. These findings demonstrate that enhanced QC measures and process improvements through LM methodology have led to measurable increases in productivity and product quality. Moreover, the reduction in defect rates further underscores the effectiveness of Lean interventions. In summary, the implementation of Lean tools has successfully reduced manufacturing time and improved OEE, thereby strengthening TNG’s operational efficiency and overall productivity.

# CONCLUSIONS

The implementation of Lean Manufacturing at TNG Thai Nguyen represents a transformative milestone that reflects the company’s heightened focus on quality assurance. This methodology has enabled the company to significantly enhance productivity, streamline production processes, minimize waste, consistently meet the stringent clients' quality requirements, and strengthen its position in the international market. This achievement underscores that LM is more than just a management methodology tool; it is a strategic approach that delivers substantial economic benefits while fostering long-term sustainable competitiveness.

In today’s era of global economic integration, Lean principles empower businesses to adapt to evolving market demands, maintain high-quality standards, and optimize resource utilization efficiently. The success of Lean at TNG Thai Nguyen demonstrates its capacity to drive continuous improvement, reduce operational inefficiencies, and establish the company as a leader in the global textile industry.

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