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Selection of Lean Manufacturing Tools for Shirt Production Lines

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ABSTRACT: *Today, the Vietnamese garment industry faces mounting pressure regarding cost, quality, and delivery time due to increasingly stringent customer requirements. For traditional garment enterprises, Lean Manufacturing serves as a strategic solution to enhance competitiveness by eliminating waste and optimizing production processes. This study analyzes waste within a shirt sewing line at GARCO10. Based on the findings, suitable Lean tools are selected and evaluated, and a structured implementation process is proposed. The research contributes to addressing operational inefficiencies, minimizing waste, and improving labor productivity. Furthermore, it provides practical insights and applicable solutions for the broader garment sector in Vietnam.*
Keywords: *Lean manufacturing, Kaizen, shirt sewing line, Muda, 5S.*

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I. INTRODUCTION

At present, the garment industry faces critical challenges in cost reduction, quality enhancement, and lead time optimization. Lean Manufacturing, centered on waste elimination (Muda) and value stream optimization, has been widely adopted across the sector. In garment production, prevalent wastes such as waiting, excess inventory, unnecessary motion, and defects frequently result in hidden costs and extended lead times. Identifying and eliminating these seven types of waste forms the cornerstone of improving production system performance.

Empirical evidence indicates that Lean implementation in textile and garment enterprises can increase productivity by up to 52% and reduce defects by 8% [8]. Furthermore, significant reductions in Work-in-Process (WIP), lower inventory levels, optimized space utilization, and faster style changeovers have been documented [1]. Operational dimensions—namely flow, flexibility, and quality—are strongly correlated with practices in human resources, supply chain management, and production system design [2]. By integrating Lean tools with process flow and cycle time analysis, productivity can be substantially enhanced, with studies showing efficiency reaching 100%, defect rates dropping to 0.08%, and WIP being virtually eliminated at the sewing line [3].

Additionally, the implementation of 5S in knitting production lines has been shown to increase labor productivity from 69.7% to 79.1% [4]. Research also highlights that factors such as component placement distance, size, and the number of fabric layers significantly influence the Standard Allowed Minutes (SAM) for Polo shirt production using single jersey fabric, following a second-order multivariable function [5]. Operator work methods and pace also play a pivotal role in labor productivity enhancement [6].

Consequently, Lean contributes to a smoother production flow, superior operational performance, and the achievement of quality, delivery, and profitability objectives [5]. In the context of rising labor costs in Vietnam and the gradual erosion of traditional competitive advantages, sustaining and leveraging Lean practices has become increasingly essential. Therefore, investigating current shop-floor conditions is of paramount importance; it facilitates waste elimination and process optimization, enabling garment enterprises to achieve sustainable development and deeper integration into the global value chain.

II. THEORETICAL BACKGROUND AND RESEARCH METHODOLOGY

Lean Manufacturing seeks to eliminate the seven primary types of waste: Overproduction, Inventory, Waiting, Motion, Transportation, Rework, and Over-processing. Core Lean tools include Value Stream Mapping (VSM) for visualizing current and future state value streams; Kaizen (continuous improvement) supported by the 5 Whys technique for root cause analysis; and 5S for workplace organization. In the garment industry, these tools are commonly integrated with line balancing and one-piece flow, both of which are highly compatible with labor-intensive production systems.

This study adopts an empirical research approach based on field observations at a shirt sub-assembly line (component section) within GARCO10. The line performs critical operations such as placket construction, pocket attachment, cuff assembly, and collar making. As these are the pre-assembly stages in the shirt production sequence, they play a crucial role in determining the workflow and efficiency of all subsequent stages. The specific product analyzed is style code CFL60464, a traditional men's shirt produced for the customer Tecovas.

The research methodology follows a structured six-step procedure:

1. Waste identification and assessment on the sewing line.
2. Development of a Current State Value Stream Map (C-VSM) to pinpoint dominant waste categories.
3. Root cause analysis utilizing Ishikawa (fishbone) diagrams and the 5 Whys method.
4. Selection of appropriate Lean tools tailored to the identified issues.
5. Suitability evaluation of the selected Lean tools.
6. Proposal of a formalized implementation process.

III. RESULTS AND DISCUSSION

3.1. Survey Results

The survey results of the sewing line were conducted to identify potential Lean wastes, as presented in Table 3.1.

Table 3.1. Current status of the shirt sewing line

No.	Category	Analysis Content	Current Status	Advantages	Disadvantages	Potential Lean Waste
1	Workforce	Size & Structure	13 permanent; 4 temporary (approx. 4 weeks of tenure)	Stable personnel; highly skilled permanent staff; temporary labor supports peak demand	Inconsistent skill levels; temporary staff yet to sync with line rhythm; over-reliance on key workers	Waiting; Motion
		Characteristics	5–15 years of experience; age 35–40; high retention	Strong discipline; stable manual motions; conducive to Lean sustainability	Resistance to change; habitual/non-standardized motions; suboptimal speed	Over-processing; Motion
2	Management	Supervision	Experience-based management (Supervisor with 28+ years of experience)	Comprehensive oversight; rapid troubleshooting	Dependence on individual expertise; lack of digitized data	Waiting
3	Machinery	Quantity	20 machines	Adequate equipment for production requirements	Excess capacity relative to workforce (17 operators)	Waiting
		Types	Single-needle, overlock, buttonhole, button attach; periodic maintenance; non-digitized	Appropriate technology; stable quality; rapid technical support	Lack of real-time data; difficulty in bottleneck detection	Waiting; Overproduction

No.	Category	Analysis Content	Current Status	Advantages	Disadvantages	Potential Lean Waste
4	Sewing Line	Layout & Flow	Linear machine arrangement; central conveyor; batch feeding	Simplified management and training; clear task allocation	Interrupted flow; lack of one-piece flow	Inventory; Transportation; Waiting
		Material Supply	Manual WIP transportation by dedicated staff	Minimizes machine downtime/interruption	Introduction of non-value-added activities	Transportation; Motion
		Work Assignment	Each operator handles one or multiple sewing operations	Clear accountability; consistent quality	Limited multi-skilling; restricted rotation flexibility	Waiting; Motion
5	Performance	Efficiency	Approximately 58%	Relatively stable output	Below Lean targets	Waiting; Inventory

3.2. Waste Identification

Based on the field survey results at the sewing lines, the following seven forms of waste have been identified:

Overproduction: There is an excess of Work-in-Process (WIP) on the production modules; processing more than the required quantity or producing items earlier than needed.

Inventory: Surplus WIP stored at various sewing workstations on the line, or idling in trolleys/bins awaiting processing or finishing.

Waiting: Operators idling while waiting for WIP from previous stages due to unbalanced line leveling (asynchronous delivery schedules) or variances in operator capacity.

Figure 3.1. Wastes related to machine downtime, work-in-process (WIP) inventory, and overproduction [7]

Motion: Unnecessary movement by operators who must leave their workstations to retrieve WIP and bring it back to their positions.

Transportation: WIP is moved across multiple areas, from the beginning to the end of the line for completion. For instance, specific tasks like pocket flap or collar turning require specialized machinery located far away, necessitating transport. This leads to increased lead time, higher labor and equipment costs, and a greater risk of damage or loss—none of which add value for the customer.

Rework: Substandard quality in certain stages forces operators to repair products during working hours. Common defects include incorrect dimensions or stitching errors that require seam ripping and re-sewing; or the use of defective raw materials in production.

Over-processing: Operators performing redundant tasks, such as adding unnecessary stay stitching on pocket flaps, repetitive WIP inspections, or over-pressing/finishing beyond the customer's quality specifications.

3.3. Proposed Solutions

According to research by Shah and Hussain (2016) and Bhutta et al. (2013), the most widely adopted Lean Manufacturing tools in the industry include 5S, Kaizen, and Quality Control Circles (QCC). Additionally, the integration of Industry 4.0 technologies to augment Lean Manufacturing is emerging as a global trend.

However, considering the constraints of traditional sewing units—characterized by limited resources yet high workloads—the implementation of Lean tools is highly appropriate to sustain and optimize existing capacities. Specifically, the Kaizen technique for eliminating the Seven Wastes (Muda) has been selected as the core approach.

The 5 Whys method is utilized to perform root cause analysis (RCA) for specific production issues. For example, a 5 Whys analysis for Overproduction Waste is conducted as follows:

- Why is there a bottleneck (work pile-up) at this operation? – Because the subsequent process is unable to keep pace.
- Why is the subsequent process unable to keep pace? – Because that operator's throughput/productivity is lower.
- Why is the operator's productivity lower? – Because the operator's cycle time is slow due to inefficient manual motions.
- Why are the manual motions inefficient? – Because of lack of focus, fatigue, or non-standardized work practices.
- Why is the operator distracted, fatigued, or failing to follow Standard Operating Procedures (SOPs)? *– (Proceed to identify the ultimate root cause).*

Kaizen is deployed via the PDCA (Plan-Do-Check-Act) cycle, focusing on continuous, incremental improvements. These efforts are measurable and visualized through Fishbone (Ishikawa) diagrams specifically developed for each category of waste.

3.4. Assessment of Lean Manufacturing tools Suitability

Product & Process Characteristics: The primary product is the dress shirt—a stable item with low variability. This consistency allows for effective Lean application without the need for overly complex tools.

Production Scale: Operated in small-batch production (17 operators, 20 machines). This scale facilitates incremental improvements at individual workstations without disrupting the entire line flow.

Labor Qualifications: The workforce consists of highly skilled permanent workers (5–15 years of experience) and quick-learning seasonal staff. An improvement mindset is already embedded within the team.

Management Capability: Leadership is fully committed to Lean principles. The corporate culture encourages Kaizen, supported by an established system of Lean KPIs to monitor performance.

Current Waste Status: Waiting, Inventory, and Transportation account for the highest proportions of waste. These are the critical areas where Lean intervention will yield the most significant impact.

Machinery Infrastructure: Equipment is stable with rapid technical support and available backup machines. This reliability significantly minimizes waste related to machine downtime (Waiting).

Step 1: Waste Identification (Plan): Conduct Value Stream Mapping (VSM) observations to identify and document the 7 Wastes (Muda).

Step 2: Root Cause Analysis (Plan): Apply the 5 Whys method to pinpoint the fundamental causes of waste and inefficiency.

Step 3: Idea Generation (Plan): Propose improvement initiatives, with a strategic priority on low-cost or no-cost solutions.

Step 4: Pilot Implementation (Do): Execute a pilot program at a single operation/workstation and monitor before-and-after KPIs.

Step 5: Evaluation (Check): Assess the results by comparing productivity and quality metrics, alongside gathering direct feedback from operators.

Step 6: Standardization (Act): Update Standard Operating Procedures (SOPs), workplace layouts, or training videos; conduct training for new staff; and perform horizontal deployment (replication) to similar operations across the line.

IV. CONCLUSION AND RECOMMENDATIONS

The research confirms that the shirt component sewing line at Dai Phong (May 10 Corporation) exhibits seven prominent Lean wastes: Overproduction, Inventory, Waiting, Motion, Transportation, Rework, and Over-processing.

Root cause analysis identifies several contributing factors: skill variances among operators, non-standardized manual motions, inconsistent WIP quality, a lack of accountability in certain workers, inaccurate planning, and limitations in line balancing and production supervision.

To address these issues and improve overall efficiency, Kaizen was selected as the primary optimization tool. The study proposes a six-step implementation framework: Waste Identification, Root Cause Analysis, Idea Generation, Pilot Testing, Evaluation, and Standardization. This structured approach ensures the effective utilization of Lean methodology.

The findings reaffirm that Lean-Kaizen does not merely reduce waste but significantly enhances the sustainable competitiveness of Vietnam's garment industry, particularly in the face of rising labor costs.

For future research and development, the team recommends:

- Implementing pilot programs for specific sub-assembly modules.
- Conducting SOP-based training for seasonal workers.
- Measuring the long-term Lean ROI (Return on Investment) over a period of 6 to 12 months to quantify the economic impact.

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