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Cost Estimation, Stitching Quality Evaluation, and Production Line Balancing in Garment Manufacturing

¹N. Sangeetha, ²A. Mohamed Shalik, ³C. Naveen, ⁴S. Naveen Kumar

¹Assistant Professor, NIFT-TEA College of Knitwear Fashion, Tirupur, Tamilnadu, India, sangeetha7988@gmail.com

²A. Mohamed Shalik, Student, NIFT-TEA College of Knitwear Fashion, Tirupur, Tamilnadu, India.

³Student, NIFT-TEA College of Knitwear Fashion, Tirupur, Tamilnadu, India.

⁴Student, NIFT-TEA College of Knitwear Fashion, Tirupur, Tamilnadu, India.

ABSTRACT

This article presents a comprehensive study on cost estimation, evaluation of stitching techniques, and production line balancing in garment manufacturing. The study aims to analyze cost components involved in garment production, assess the impact of different stitching techniques on product quality, and optimize workflow in sewing units through line balancing techniques. Data was collected from a knitwear manufacturing facility through observations, interviews, and time-motion studies. The findings highlight key cost drivers, demonstrate the relationship between stitching methods and garment durability, and propose solutions to reduce bottlenecks and improve labor utilization in sewing lines. This multidisciplinary approach provides actionable insights to enhance production efficiency and product quality in apparel manufacturing.

Keywords: Cost estimation, Stitching techniques, Quality assessment, Line balancing, Workflow optimization, Garment production, Sewing efficiency

1. Introduction

The global garment manufacturing industry is a highly competitive and dynamic sector that requires constant innovation and efficiency improvements to maintain profitability and meet market demands (Khurana, 2012). Manufacturers must carefully balance multiple factors such as cost, quality, and production speed to remain competitive in both domestic and international markets (Tyler, 2008). Among these factors, cost estimation plays a pivotal role in strategic decision-making, pricing, and resource allocation. Accurate cost estimation not only affects profitability but also helps in identifying potential areas of waste and inefficiency, enabling targeted interventions for cost reduction (Khanna & Singh, 2015). It requires a detailed understanding of the material costs, labor inputs, overhead expenses, and process-specific variables associated with garment manufacturing (DeGarmo, Black, & Kohser, 2003).

In parallel, the quality of stitching is a fundamental determinant of garment durability, fit, and consumer satisfaction (Cooklin, 2009). Stitching methods vary widely, ranging from lockstitch, chain stitch to overlock and coverstitch, each offering distinct advantages and limitations in terms of strength, flexibility, and production speed (Nayak, Padhye, & Wang, 2015). The choice of stitching technique has a direct impact on product performance, including seam strength, appearance, and resistance to wear and tear (Sangeetha & Kumar, 2021). Improper stitching can result in seam failures such as puckering, skipped stitches, and seam slippage, leading to increased rework costs and potential customer dissatisfaction (Tyler, 2008; Das & Alagirusamy, 2010). Therefore, evaluating stitching techniques through both mechanical testing and visual inspection is critical for maintaining consistent garment quality.

Moreover, the sewing department often serves as a production bottleneck due to the labor-intensive nature of stitching operations and variability in operator skill levels (Anand & Muthiah, 2018). Production delays, idle time, and uneven workload distribution commonly reduce sewing line efficiency, resulting in increased lead times and higher production costs (Rajamanickam, 2013). To address these challenges, production line balancing techniques have been widely adopted to optimize workflow by distributing tasks evenly across operators, minimizing idle time, and maximizing labor utilization (Islam & Khan, 2016). Proper line balancing improves overall production capacity, reduces worker fatigue, and enhances product consistency (Pal & Gander, 2018).

Previous research emphasizes the importance of integrating cost control, quality assurance, and workflow optimization to achieve sustainable improvements in garment manufacturing performance (Kumar & Nambiar, 2014; Sinha & Uniyal, 2017). However, studies that holistically address all these facets within the context of knitwear production remain limited. This study bridges this gap by conducting a detailed investigation into the cost structure of garment production, assessing the quality impact of various stitching methods, and applying line balancing principles to enhance sewing efficiency. Through a combination of empirical data collection, tensile testing, and workflow analysis, the study aims to generate actionable insights that can be directly applied to optimize knitwear manufacturing operations.

This integrated approach not only aligns with the increasing industry focus on lean manufacturing and quality management but also supports academic learning objectives related to process documentation, analysis, and improvement in apparel production (Sangeetha, 2019). By addressing these interconnected areas, this research contributes to both practical industrial advancements and the development of future-ready professionals equipped with critical analytical and problem-solving skills.

2. 2. Methodology

2.1 Research Design

This study employed a mixed-methods approach combining quantitative data collection with qualitative observations to comprehensively analyze cost estimation, stitching quality, and production line balancing within a knitwear garment manufacturing setting. The research was conducted over a one-month period at a mid-sized knitwear manufacturing unit located in Tirupur, India. The unit was selected due to its representative production scale and adoption of varied stitching techniques common in the knitwear industry.

2.2.1 Cost Estimation Data

Primary data on cost components were collected from the finance and production departments of the manufacturing unit. The cost elements analyzed included raw materials (fabric, threads, accessories), direct labor wages, machine operational costs (electricity, maintenance), and overhead expenses (factory rent, utilities, administrative costs). The data were gathered from purchase invoices, payroll records, and production logs spanning the study period. Each cost item was allocated to individual garment styles and production stages to enable detailed cost breakdown and variance analysis.

2.2.2 Stitching Quality Evaluation

For the stitching quality assessment, samples of garments produced using three commonly employed stitching techniques — lockstitch, chain stitch, and overlock — were collected from production batches. Each sample underwent mechanical testing to measure seam strength using a universal tensile testing machine following ASTM D1683-09 standards. The samples were subjected to controlled tension until seam failure, with maximum load recorded for comparative analysis.

In addition to mechanical testing, a visual inspection was conducted to identify common stitching defects such as puckering, skipped stitches, seam slippage, and inconsistent seam allowances. Inspections were carried out by trained quality control personnel using standardized checklists. Operator interviews were conducted to collect qualitative insights regarding challenges faced during stitching and perceived quality issues.

2.3 Production Line Balancing Study

The production line balancing study involved detailed process mapping of the sewing department. The entire sewing operation was decomposed into discrete tasks, each timed using a stopwatch method to record task durations with an accuracy of ± 0.1 seconds. Data were collected across multiple operators and shifts to capture variability.

A Gantt chart was constructed to visualize task sequencing, workstation utilization, and idle times. Line balancing algorithms based on the Ranked Positional Weight (RPW) method were applied to redistribute tasks and optimize the workload among sewing stations. Metrics such as line efficiency, smoothness index, and operator idle time were calculated pre- and post-optimization to evaluate the effectiveness of balancing interventions.

2.4 Data Analysis

Quantitative data were analyzed using descriptive statistics to summarize cost distributions, tensile strengths, and time measurements. Comparative analysis was performed to identify significant differences in seam strength among stitching techniques using one-way ANOVA with a significance level of $p < 0.05$.

Qualitative data from visual inspections and operator interviews were coded thematically to extract recurrent quality issues and operator perceptions. These insights complemented quantitative findings to inform recommendations for process improvements.

2.5 Ethical Considerations

The study was conducted with the full consent of the manufacturing unit management. Confidentiality of proprietary financial data and employee information was maintained throughout. Operators participating in interviews were informed of the study's objectives and assured of anonymity.

3. Summary

This study undertook a comprehensive examination of three critical facets of garment manufacturing—cost estimation, stitching quality assessment, and production line balancing—within a knitwear production environment. The cost analysis revealed that raw materials constitute the largest proportion of

total garment cost, accounting for nearly two-thirds of expenses, followed by labor costs and overheads. This underscores the importance of effective material utilization and cost control mechanisms to enhance profitability. The evaluation of stitching techniques highlighted notable differences in seam performance; lockstitch seams exhibited superior tensile strength and fewer defects compared to chain stitch and overlock seams, which, despite offering faster production rates, were more prone to quality issues such as seam slippage and skipped stitches. These findings emphasize the trade-offs manufacturers face between production speed and garment durability. The production line balancing investigation identified inefficiencies caused by uneven task allocation and operator variability, resulting in considerable idle time. Implementation of line balancing strategies led to a marked reduction in idle time and improved line efficiency, demonstrating the potential for workflow optimization to enhance throughput and reduce labor costs. Collectively, the integrated findings provide a nuanced understanding of how cost factors, stitching quality, and operational workflow interact to influence overall manufacturing performance.

4. Conclusion

The present research confirms that a holistic approach integrating cost analysis, stitching quality evaluation, and production line optimization is essential for improving the competitiveness and sustainability of garment manufacturing operations. Accurate cost estimation enables manufacturers to identify primary cost drivers and allocate resources more effectively, ultimately supporting better financial planning and pricing strategies. Evaluating stitching techniques through both mechanical testing and defect analysis reveals that quality cannot be sacrificed for speed without risking product failure and customer dissatisfaction; thus, investments in operator training and quality control are justified. Moreover, addressing inefficiencies in the sewing line through systematic line balancing fosters improved labor productivity, minimizes bottlenecks, and enhances workflow continuity. These improvements not only reduce production lead times but also contribute to higher product quality and worker satisfaction. The study's recommendations advocate for a balanced focus on cost management, quality assurance, and operational efficiency, providing a valuable framework for knitwear manufacturers seeking to optimize their production systems. Future research could explore the integration of automation and digital monitoring tools to further enhance precision in cost tracking and workflow management.

References

1. Anand, S., & Muthiah, K. (2018). Material Resource Planning in Apparel Units: A Study on Knitwear Clusters. *Journal of Textile and Apparel Technology and Management*, 11(2), 22–31.
2. Cooklin, G. (2009). *Introduction to Clothing Manufacture* (2nd ed.). Blackwell Publishing.
3. Islam, M. M., & Khan, A. M. (2016). Improving Production Efficiency through Lean Tools in Knit Garments. *International Journal of Textile and Fashion Technology*, 6(4), 1–10.
4. Khurana, K. (2012). *Introduction to Apparel Manufacturing*. New Age International Publishers.
5. Kumar, B. S., & Nambiar, P. (2014). Time and Motion Study in Apparel Production Line. *International Journal of Engineering Research & Technology*, 3(12), 1458–1462.
6. Nayak, R. K., Padhye, R., & Wang, L. (2015). *Garment Manufacturing Technology*. Woodhead Publishing.
7. Pal, R., & Gander, J. M. (2018). Efficiency Improvement through Line Balancing in Knitwear Garment Industry. *International Journal of Industrial Engineering & Production Research*, 29(3), 157–164.
8. Rajamanickam, M. (2013). Apparel Production: A Systems Approach. *Textile Value Chain Journal*, 2(1), 41–47.
9. Sangeetha, N. (2019). Efficiency Improvement Techniques in Knitwear Production. *Journal of Textile and Apparel Management*, 12(2), 45–53. NIFT-TEA College of Knitwear Fashion, Tirupur.
10. Sangeetha, N., & Kumar, R. (2021). Time and Motion Study for Productivity Enhancement in Sewing Operations. *International Journal of Apparel Technology*, 14(1), 27–35. NIFT-TEA College of Knitwear Fashion, Tirupur.
11. Sinha, K., & Uniyal, D. P. (2017). *Managing Productivity in the Apparel Industry*. CRC Press.
12. Tyler, D. (2008). *Clothing Manufacturing: A Technical Approach* (4th ed.). Blackwell Publishing.
13. Das, A., & Alagirusamy, R. (2010). *Science in Clothing Comfort*. Woodhead Publishing.
14. DeGarmo, E. P., Black, J. T., & Kohser, R. A. (2003). *Materials and Processes in Manufacturing* (9th ed.). Wiley.
15. Khanna, A., & Singh, R. (2015). Cost Analysis in Garment Manufacturing: Case Studies from Indian Knitwear Units. *Indian Journal of Textile Science*, 40(3), 215–223.