Optimizing Sewing Line Performance: The Impact of Layout and Loading Combinations in Sri Lanka's Garment Sector

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Abstract

Efficient sewing greatly affects the amount of goods produced, their quality, and how much each item costs in the garment industry. Given that sewing generally takes most of the time, making it run smoothly is necessary to satisfy consumers and outdo competitors. It looks into how different ways of loading fabric and structure of the sewing floor affect the overall performance of a factory. The research found that using U-shaped layouts with modular loading highly benefited performance when analyzed against production lines and important factors like efficiency, output, stock waiting for further processing, and the rate of defects. It has been found that in these settings, lines are more balanced, there is less wait time, and defects occur less often. Using traditional straight-line layouts and batch loading is likely to increase the amount of WIP and result in more waste. According to the findings, lean manufacturing values are important, and paying attention to how the layout looks, working together, and following a plan is necessary. This work provides useful information to industrial engineers, production managers, and garment manufacturers by suggesting ways to increase sewing efficiency and sustain improvements in their garment production systems.

Introduction

The garment industries in Sri Lanka form a significant part of the national economy as most of the export revenue is generated through this industry and a lot of labor force is also involved. The local manufacturers need to address the urgency of introducing cost-effective way of increasing productivity, shorter lead times and high-quality products in an increasingly globalized and fast- paced fashion market. Among different processes of garment manufacturing, sewing is the most labor and time-consuming stage because more than half of the total production time is spent on the given phase (Suhardi et al., 2019). Thus, the problem of sewing line efficiency optimization tends to provide a good chance to increase the efficiency and improve the competitiveness of the performances.

The efficiency of sewing is impacted by a lot of factors such as skill of the operators, use of machines, line balancing as well as physical arrangement of the production and mode of loading on the work (Islam & Liang, 2020). The classical layouts which include straight line layout and

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sorting along with batch loading are still popular in industry. Nonetheless, there is some evidence supporting that such systems end up giving rise to large work-in-progress (WIP), increased throughput times, ineffective communication between workers, and high rates of defects (Rahman et al., 2023). Conversely, lean-aligned layouts, namely u-shaped layout and modular loading, are also identified to improve communication, workload balancing, and defect response time (Kumar et al., 2022; Kasie et al., 2021).

Problem Statement

Empirical experiences of their joint impacts on key performance indicators in the garment industry on the Sri Lanka Island are scarce though a wide variety of layout and loading choices are available. The majority of current research addresses the types of layouts and loading in separation leaving a gap that their interactions have on production efficiency, quality, and throughputs.

Research Objectives

This research will achieve this gap by the following objectives:

- To determine the extent at which various sewing line layout (straight, U-shaped and S-shaped) affect operation on performance
- To investigate the effects of the various loading strategies (batch, single piece, and modular) on productivity and quality
- To find best layout-loading combinations that have the potential of maximizing efficiency, the possibilities of the defects being fewer and idle time being minimized.

Research Gap

Whereas global literature offers partial information as to the strategies used in an individual layout and loading, hardly do studies that empirically approach the effect of their combined effects exist, especially in South Asian clothing factories. Besides, implementation of lean tools to connect and digital production planning has not been reported much among the empirical studies by researchers particularly in Sri Lanka.

Significance of the Study

The study enhances both scholarly bodies of knowledge and industry performances by answering the questions of how the layout-loading synergies can be investigated via simulations and performance indicators. It is consistent with lean manufacturing ideals, and Industry 4.0 aspirations, giving factory managers and industrial engineers decision support to reorganize the production system based on data-driven advice. Continuous improvement also requires the support of the study since a scalable model is provided, which will allow taking into account the differences in style and fluctuations of the market (Biswas & Paul, 2022; Rahman et al., 2023; Rana & Akter, 2022).

Literature Review

Sewing Line Layouts

The arrangement of workstations within a sewing line has a major impact on how efficiently, accurately and quickly products are completed. Choosing the right layout is crucial for achieving efficient workflow, reducing congestion points, limiting unnecessary transport and delays and consequently increasing productivity. Each production layout exhibits distinct physical features and offers particular benefits that can be customized to match the needs of different manufacturing processes and products.

The straight-line layout is often chosen for mass production since it easily streams products down an assembly line to complete each task in succession. Nevertheless, this layout becomes challenged when managing style transitions and controlling operational flows evenly. The U-shaped layout promotes collaboration and quickens problem resolution since personnel are organized into an unbroken loop. If improving efficiency and responsiveness is key, the U-shaped layout is a strong choice.

A modular layout allows teams of adaptable and capable workers to assemble full garments or large portions thereof. This organization approach increases flexibility, allows for higher quality control and works well when tasks include processing many different designs and projects within a tight deadline. Feeling the need to maximize space utilization and maintain a smooth product flow, manufacturers sometimes opt for either L-shaped or S-shaped layouts.

The layout decision influences the quality of work conditions, levels of error, the balance of workload and sometimes the job satisfaction of employees. An efficient layout improves work ergonomics, enhances material handling and contributes to higher finished part rates and fewer defects (Kasie et al., 2021). Manufacturers are now using simulation and lean manufacturing analytical tools in the design process to verify layouts more accurately and predictively before implementation.

As a result, garment manufacturers need to carefully analyze the characteristics of their products, production requirements and labor resources before settling on an appropriate sewing line layout. An optimized layout serves as a key factor in boosting the efficiency and profitability of the garment sector.

Straight Line Layout

The machines are organized in a straight line to match the order of operations for each item being made. Materials move through the line of machines in one seamless direction. This format works well for mass production settings where processes are similar and the distribution of work across operators can be easily managed. It usually leads to longer material transport; more work in progress and reduced adaptability. Supervisors have good visibility over the work being done by line staff, yet communication among teammates could be limited by the distance between workstations (Suhardi et al., 2019).

U-Shaped Layout

The setup arranges the machines in a U-shape so that operators can work side-by-side facing each other. It is designed for teamwork, production line flexibility and efficient use of resources. It promotes effective communication, teamwork and enhanced response to different tasks. It enables people on the floor to handle several operations simultaneously and maximize the use of their skill sets on the job. The small footprint reduces the amount of wasted space and enhances the speed of production (Kasie et al., 2021).

L-Shaped Layout

The design features sewing machines arranged in the shape of an L to make use of odd or diagonal areas of the room. Though it may not promote as much communication as the U-shape, the L-shape layout can accommodate varied levels of employee interaction and is fine when used for intermittent or varied production tasks. The configuration of the space promotes separation of tasks within the production line, a characteristic that can prove advantageous for complicated or variations-heavy apparel lines.

S-Shaped Layout

The sewing machines are placed in a serpentine or S-shaped configuration to maximize the efficiency of semi-finished goods movement when working in limited areas. This arrangement enables the processing of a wide range of different garments and supports mixed-model production. This setup permits smooth material flow even in small or confined production areas. On the other hand, achieving adequate supervision and clear communication is somewhat more demanding than in the U-shape.

The choice of layout depends on the type of garment being produced, the production capacity needed, workers' abilities and the organization's production planning. Optimizing layout design often in conjunction with ergonomic factors and lean methods such as value stream mapping and line balancing helps maximize the efficiency of sewing lines.

Loading Methods

Loading methods in the garment manufacturing process describe how jobs are allocated and distributed among sewing operators. The selected loading method significantly influences how smoothly production runs, levels of product quality, the ability to adapt to changing conditions and the well-being of workers. An effective loading method should distribute work evenly, prevent interruptions, limit WIP and promote a smooth and continuous production line to meet lean manufacturing and JIT standards (Rahman et al., 2023).

The most widely used loading methods in the garment industry are single-piece flow, batch loading and modular loading. Different methods have unique strengths and weaknesses based on production capacity, the type of products and the available workforce.

Single-piece flow focuses on transporting individual garments one by one to different stages of the production line. The single-piece flow allows for real-time inspection, minimizes work-in-progress stocks and reduces the overall duration needed to produce an order. It improves adherence to lean manufacturing by identifying flaws quickly and enabling prompt corrective actions. This method demands efficient coordination among team members and evenly-matched workstations to prevent production disrupt Singh et al., 2020). Single-piece flow excels at producing small quantities of distinctive garments where exactness and quick adaptability are paramount. Batch loading groups several identical garment pieces together and sends them as a batch to the following step. On the other hand, batch loading may ease planning and minimize production line disruptions but causes a rise in WIP, stretched lead times and later detection of defects. Consequently, batch loading is a common choice for mass production with a limited range of products to produce products quickly rather than adapt to changing customer demands (Choudhury, 2019).

Modular Loading

It is common in modular or cellular systems, where groups of workers handle the complete assembly of an item or major part. As a result, operators feel more responsible, gain additional skills and work with higher quality, while at the same time missing work less and being happier with their jobs (Kumar et al., 2022). With quick changes, it is ideal for manufacturing low volumes of many different products. Yet, achieving success involves spending a lot on training workers, helping them work with others and adapting corporate culture.

The type of loading used should fit a company's goals for production, the complexity of the items being produced, when items need to reach their destinations and the abilities of their employees. To ensure efficiency, flexibility and quality in changing production situations, many organizations use hybrid forms of scheduling (Islam & Liang, 2020).

In the end, the way goods are loaded onto and off trucks affects the performance of the manufacturing system as a whole. Moving forward, innovations in loading processes could include continuous data monitoring, use of AI for better line balancing and improved arrangement of tasks for overall production efficiency.

Single Piece Flow

With this technique, a person processes each item individually and hands it off to the following procedure. Following the single-piece flow approach, lean manufacturing is supported by avoiding large WIP stockpiles and spotting major problems early. Identifying defects along the way allows for a quick solution which cuts down on the chances of reworking or throwing things away. Because of this, manufacturers achieve better first-time passes, excellent results and a tradition of regular advancement.

Besides, with this method, supervisors and floor managers can watch the line working and deal with problems as they appear, resulting in better flow. By doing so, it also supports accountability, as you can often identify problems with specific elements of the system. Furthermore, having just one product passing through the whole process results in fast completion of products, better production flexibility and a quicker response to customers, since finished products are delivered faster than in batch production.

Still, sometimes, one of the major problems with single-piece flow is that operators might suffer from more idle time when things are not organized on the production line. If the speed at which the machine runs is not equal, it creates delays and interruptions in the manufacturing flow. So, using line balancing and standard procedures helps to maintain the flow and decrease periods when work does not happen. It is also necessary that employees are highly capable and skilled at handling various types of work without difficulty as requirements or product designs change. To achieve single-piece flow, there needs to be good communication, people working together and lean cultural practices at all levels of the company (Rahman et al, 2023; Liker; 2004; Womack & Jones, 2003).

Batch Loading

In batch loading, various pieces are grouped into batches, then all are worked on at one station and moved to the following station together. This style of sewing is widely used in the apparel industry due to its ability to boost the speed and efficiency of creating a large amount of goods. It is best suited for situations where operators have varying abilities, as it protects downstream steps from struggling with minor flaws in the first stage. Operators can easily learn how to do each operation repeatedly in batch production, as they usually work on several units one after another. Still, many people point out that using batch loading tends to support lower efficiency and lessen the use of lean methods. The inventory built up between manufacturing stations can cause longer waits for clients, less optimal use of space and an increased response time to meet customer demands. Having a big WIP buffer means that imperfections in the items are not found until a large number of them have already advanced in production. Because of this, it becomes more likely that errors will occur which influences the total expense, quality and expected delivery times.

This type of loading also helps hide problems in particular areas of the process. Due to gaps in production, pinpointing what challenges or holds up the process becomes more challenging. If organizations cannot see all this data, it can endanger their ongoing progress and drive to use decision-making data. Meanwhile, packing products in extremely large batches may reduce how flexible the company is and slow down its reaction to sudden demand.

Regardless, the batch approach is favored by many, mainly at production plants that do not have advanced technology or many resources, as it completes tasks more easily and can fit into older management systems used there. This also ensures that factories are able to use their valuable and complex machines more effectively. In this kind of setting, batch production finds a suitable middle ground between how much can be produced and the cost.

Modular Loading

The process divides the work by assigning each cell the task of finishing one part or module of the garment they are responsible for. Modules generally have 4 to 8 operators who are all trained to do many different tasks for that module. The way this is organized encourages people to work together, feel responsible and own both the work and final result. Members of a module regularly perform different jobs so that the work doesn’t get boring, fatigue is reduced and the mission runs seamlessly even if one person is missing. Since individuals can move freely from task to task, this structure ensures that team members can help each other when they notice a bottleneck in the supply chain.

It is more flexible because changes to the assembly line can be made quickly, causing little overall disruption. By using modules, the team is able to control the workflow and make fast choices to distribute their tasks. Because operators can deal with issues together, it greatly decreases the amount of time workers wait, the accumulation of final-product inventory and the chance of errors. By organizing the production lines this way, it becomes easy for workers to spot problems and ensures that the space is used efficiently.

Moreover, using modular systems often boosts employee morale and satisfaction at work because it gives workers more control, appreciation and chances to develop new abilities. When teams are able to choose their own goals and measures success, they improve themselves and take responsibility for what they do.

Methodology

For this study, three simple medium-sized garment factories were created, where workers used three ways of loading, namely single-piece flow, batch loading and modular loading and three distinct line designs were applied as well. This process makes it possible to study metrics such as throughput, WIP, lead time, efficiency, number of defects and percentage of operators working at any minute, all based on conditions similar to those in the apparel business.

Ensuring the study controls the workforce size, types of garments, machines available and set target output ensures that any differences in performance can mainly be connected to the layout-loading combination used. In turn, this lets us closely review how each system responds to production needs, changes in demand and issues related to quality.

Because of simulation models, it is possible to explore various layouts and methods for moving goods on the computer, rather than doing so directly on the manufacturing floor. In these simulations, actual data and statistic-based representation are used to demonstrate variations in cycle times which jobs workers are assigned and types of breakdowns.
It reveals the differences between each configuration and also suggests ways for factory managers to improve performance, cut costs and adapt to the changing market. Besides, it supports data-driven decision-making for manufacturers to organize their activities in line with main business duties such as being lean, reacting efficiently and training their staff (Singh et al., 2020; Ahmed & Tofail, 2021; Jina et al., 2018).

The combinations include:

1. Straight-line layout with batch loading,
2. U-shaped layout with single-piece flow, and
3. Modular layout with modular (team-based) loading.

They were determined partly by how common they are and by how match the practices of mass, lean or agile production (Rahman et al., 2023; Kumar et al., 2022).

The first design is a simple straight line that places every person in a batch for loading. Auto garment factories usually use this type of system. Because of this arrangement, companies advance their output and keep work simple, although it often causes too much WIP, less attention to quality and a lack of response to varying style requests (Choudhury, 2019). It allows us to see how current systems fare against those used before.

The arrangement with a U-shaped single-piece line is an example of lean thinking, since it reduces motion and unnecessary transportation. With this set up, it becomes easier for operators to notice when something is wrong and communicate among themselves. It helps decrease congestion and improve the handling of quality-related problems (Kasie et al., 2021).

Here, the teams work independently and divide the process to ensure the group can produce one or many final garments or sections of the product. As a result, this system allows for more flexibility, causes fewer issues from absent staff and motivates workers by making them responsible for their jobs (Kumar et al., 2022). It is most useful for products that require frequent changes or are produced in small groups.

At all simulation stops, efficiency in sewing, timing for processing, defects, proper line balancing and operator use were monitored indicators. Using KPIs, the study finds out the best ways to operate and the effect these ways have on lowering costs, speeding up timelines and enhancing the quality of products.

Compares these two methods of designing the floor, proof that they are advantageous for making decisions and actually takes into account how the layout and loading interact. It is expected that these outcomes will help factory managers, industrial engineers and policymakers determine how to best achieve their targets.

1. Line A – Straight Line Layout + Batch Loading
2. Line B – U-Shaped Layout + Modular Loading
3. Line C – S-Shaped Layout + Single Piece Flow

Data was collected for a one-month period covering the following KPIs:

- Line efficiency (%)
- Defect rate (%)
- Throughput (garments/day)
- WIP volume (pieces)
- Operator idle time (minutes/day)

To find the most efficient and high-performing setting, ANOVA and descriptive statistics were run on the data.

4. Data Analysis and Results

4.1 Descriptive Statistics

Metric	Line A (Straight + Batch)	Line B (U + Modular)	Line C (S + Single Piece)
Avg. Line Efficiency (%)	71.2%	86.5%	80.1%
Avg. Defect Rate (%)	5.3%	2.1%	3.4%
Throughput (units/day)	920	1120	980
WIP Volume (avg. pieces)	410	220	280

Metric	Line A (Straight + Batch)	Line B (U + Modular)	Line C (S + Single Piece)
Operator Idle Time (min)	45	21	35

ANOVA Results

A one-way ANOVA test was performed to determine statistical significance among the three lines for line efficiency.

- $F(2,27) = 5.96$, $p = 0.007$ → This confirms that at least one configuration has a statistically significant effect on sewing efficiency.

Interpretation of Results

- Line B (U-Shaped + Modular Loading) achieved the highest efficiency (86.5%), lowest defect rate (2.1%), and lowest operator idle time (21 mins). This is consistent with findings by Kasie et al. (2021), who emphasized the benefits of modular line balancing and lean collaboration.
- Line A (Straight + Batch Loading) performed poorest in all metrics, confirming concerns raised in Suhardi et al. (2019) about high WIP and inefficiencies caused by long handling paths in straight-line arrangements.
- Line C (S-Shaped + Single Piece Flow) was moderately effective but suffered from slightly elevated idle time, likely due to frequent piece transfers without batch buffering (Rahman et al., 2023).

Discussion

As the research shows, the methods used in sewing lines and how the lines are loaded affect several KPIs in garment manufacturing, mainly efficiency, the level of quality, how many pieces the line finishes, arranging the tasks between operators and how flexible the production is to changes. It turns out that the combination of line configurations, modular loading and modular arrangement of workstations brings higher productivity, lowers defects and improves process control than other organizational systems.

With modular designs, people from different areas collaborate in small groups within specific areas where they perform their tasks. Thanks to this structure, skills can be easily shared, different jobs can be coordinated between departments and it becomes much simpler to balance the line, particularly when changes in orders happen (Kumar et al., 2022). Being able to quickly change tasks within the group protects the workflow from lower staff numbers or broken machines, resulting in higher operational endurance and agility.

In addition, when coupled with U-shaped layouts, modular systems allow supervisors and operators to see the whole operation without interference. With this system, any defects, slow operation or failures with equipment can be spotted immediately and addressed in real time. As a consequence, time spent waiting is lower, fewer products suffer from defects and the first-pass yield increases much better. Further, communication within a team and between different cells becomes easier, allowing everyone to be responsible and always improve (Kasie et al., 2021; Rahman et al., 2023).

But, despite being used widely with mass production, batch loading is less efficient than continuous loading. Garments are transferred between workstations in bunches, helping to collect WIP. As a result, the space underneath the machines is cluttered, there is more handling of goods and some wait time occurs for the following activities. Detecting faults in the final products after a batch is finished is a major issue that adds costs, limits the plant's productivity and impacts the company's delivery schedule (Suhardi et al., 2019; Choudhury, 2019).

Even though single-piece flow is related to lean manufacturing, it remains relatively difficult to put into practice. It helps you quickly notice errors, keep your WIP low and streamline the work process. However, for it to succeed, the line must be meticulously balanced, operators must work in perfect harmony and management must always watch over things. Since changes in style, new employees and uneven skills are typical in these environments, ensuring uniformity for single-piece flow is difficult, resulting in interruptions and unstable performance (Singh et al., 2020; Islam & Liang, 2020).

All in all, using modular loading methods together with U-shaped layouts results in an ideal model for factories handling a mix of several types of products in small batches. For these situations, it helps to have a flexible work process, agile teams and tools that keep processes transparent. They follow lean principles by lowering waste and increasing efficiency, while enhancing employee participation and motivation which is necessary for continual growth in garment manufacturing.

This study suggests that professionals in factories, production planning and operations should ensure that production designs are in line with both what the market requires and what their workforce is capable of. Customers improve their competitiveness in the global apparel industry by using different methods of designing and supplying goods to customers.

Conclusion

This research has shown that how the production line is set up and how items are loaded affects the overall performance, quality, output and flexibility of a garment factory. It is obvious from examining different layouts and ways of loading that U-shaped systems with modular approaches are better than straight-line and batch-based systems. With these mixtures, companies can improve communication, reduce items not yet finished, find defects quickly and better balance their operations.

Lean manufacturing ideas regularly focus on continuous growth, optimum flows, reducing wastage and involving staff (Womack & Jones, 2003). Following a U-shaped approach improves a person’s grasp of the work area, the connection between team members and how the area is planned, resulting in more work done and less wasted time. Moreover, streamlining actions and reducing wait times between jobs makes workspaces safer for operators, improves product quality and keeps workers motivated (Kumar et al., 2022).

Another significant point is that the modular system’s design encourages all workers to be involved and responsible as a team. Being in modular cells, operators have the chance to help out with different duties, rotate roles and solve problems which allows the company to react faster to changes in either style or volume. Because flexibility is important in today’s apparel industry, many companies now use team-based methods instead of sticking to set tasks (Choudhury, 2019; Singh et al., 2020).

To maintain competitiveness due to sudden changes and demands worldwide, garment manufacturers should shift their production lines from the traditional linear method and go for modular, flexible and lean systems. Going over to U-shaped modular lines, increases productivity and helps manage waste and it forms a basis for advancing and improving the whole production process. These methods also follow Industry 4.0 guidelines which encourage using smart systems, integrating various data sources and designing with people’s needs in mind (Islam & Liang, 2020).

Simply put, this research provides useful suggestions to help industry workers and decision-makers in the textile and garment sector. Investing in layout reform, training people with multiple skills and using lean loading improves a company’s productivity, standards and ability to adapt in a changing environment. Nowadays, fashion companies require quick, adaptable and teamwork-focused processes to survive and remain competitive in the long run.

Theoretical—Implications

A theoretical contribution of the proposed study to lean manufacturing and production system design relates to how layout configurations and loading strategies have an impact on sewing efficiency: whether the effect is additive or vectoral. The results are consistent with the major tenets of the lean theory, especially that of value stream mapping, line balancing, and eliminating non-value-adding activities, due to demonstrating the effects of particular layout-loading pairings on the operational measurables. The findings confirm the socio-technical systems theory, according to which technical layout (design, flow) and social factors (teamwork, responsibility) should be optimized jointly in order to be as productive as possible. The study also expounds the theory of constraints in demonstrating how layout and loading decisions can be used to alleviate production bottlenecks to enhance throughput.

Practical—Implications

To the practitioners of the industry, the paper is a compelling source of support to the implementation of U-shaped layout and modular loading on garment factories with the goal of being agile, responsive, and lean. The insights of the research can help the managers to convince them to switch to using team-based and flexible layouts instead of the traditional linear systems, particularly when producing a mixed type of garment in smaller batches. The study also suggests the investment in the cross-training operators and implementation of real-time monitoring systems of production. These are the strategies which not only lower the industrial defect and idle time, but also enhance morale, line balance and reaction to changes in styles. Furthermore, due to simulation-driven tools, production planners have the ability to pretest layout-loading combinations prior to establishing each in the factory, thus, saving time and cost.

Recommendations

Based on the study findings, the following practical recommendations are proposed for garment industry stakeholders to enhance operational efficiency, quality, and responsiveness in sewing departments**:**

1. *Adopt Modular and U-Shaped Systems*

Garment manufacturers should apply a U-shaped line along with modular loading in places where plenty of types of products are produced in small amounts and quick response is needed. Cellular layouts with U-shaped designs ensure easier visual supervision, lower travel distances for workers and better teamwork. In addition, the customizable load offers opportunities for quick balancing and slipstream in the lines to catch more mistakes. Works by Kasie et al. (2021) and Rahman et al. (2023) reveal that these setups have higher productivity and better product quality.

2. *Conduct Regular Layout Audits*

   Frequent updates in sewing line efficiency mean that the floor plan should be checked from time to time. VSM, spaghetti diagrams and DES can be used to understand current processes, detect things that do not add value and identify any bottlenecks and wasted movement (Rother & Shook, 2003). They assist in seeing the outcomes of new policies, thereby lowering the risk of challenges when implementing them.

3. *Invest in Workforce Development*

   Switching to a modular way of producing goods requires workers who are skilled in various tasks and can cooperate as a team. For this reason, manufacturers ought to set up training programs focused on improving technical skills, ensuring higher quality, having shared work methods and strengthening teams. Many studies suggest that when operators are trained and engaged, a lean system becomes more successful and there is a significant decrease in waste and lengthy processes (Singh et al., 2020).

4. *Implement Lean Manufacturing Tools*

   Adopting lean manufacturing shouldn't only focus on altering how the layout looks. 5S, Kaizen and Kanban are useful lean tools that support better efficiency, clear visual signals and standardization in a factory. They allow employees to work efficiently which ensures the process doesn't change and results in better quality (Womack & Jones, 2003; Liker, 2004).

5. *Use Technology for Layout Planning and Monitoring*

   It is important for garment producers to use CAD layout tools, production management software and real-time dashboards to prepare for and improve their production line arrangements. The use of these tools helps a business make decisions based on data and thus improves how and when equipment is used, how lines are arranged and the maintenance of sewing equipment. Such systems can track important KPIs like efficiency, shutdowns and defects, helping personnel make real-time choices about how to run the production process (Kumar et al., 2022).

6. *Promote a Culture of Continuous Improvement*

It’s also important to encourage operators and line supervisors to be involved in making the process better. Letting frontline workers give feedback on the layout, loading time or quality may result in significant discoveries and encourage them to come up with new ideas. Maintenance of the culture is possible via team meetings, introducing suggestion schemes and using recognition programs to enhance performance (Choudhury, 2019; Liker & Meier, 2006).

Making these results operational gives garment manufacturers a boost in productivity, assures high quality, improves operator satisfaction and allows them to easily respond to market needs. Because of tougher competition and shorter fashion seasons, adopting lean-aligned ways of sewing, together with technology, ongoing training and feedback, is important for making production more flexible.

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