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Original Article

Applying a People-Centric Reliability Method to Boost Productivity and Employee Well-being: A Case Study in the Marine Canvas Industry

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Abstract *- This case study addresses the challenge of increasing throughput without significant capital investment by applying the Sawhney people-centric framework in a marine canvas company. This approach integrates Systems Thinking and Lean to enhance resource reliability through employee-centered strategies. A diagnostic phase, including time studies and reliability assessments, identified critical bottlenecks, workload imbalances, and high non-value-added activities rooted in human and informational reliability. In response, two line balancing strategies were developed. A no-cost personnel reallocation projected a roughly 56% productivity increase (from 16 to 25 units/day), while a modest investment in two additional workers could raise output by approximately 162% (to 42 units/day). Beyond these operational gains, the strategies also reduce employee stress and improve process stability. This study distinguishes itself from much of the existing Lean and Operational Excellence literature by offering an empirical application of a people-centric reliability framework in a small, high-mix, manual production environment. This demonstrates that a people-centric approach offers a powerful, low-cost pathway to sustainable operational Excellence in manufacturing, directly addressing the gap between theoretical human-centric paradigms (e.g., Industry 5.0) and practical, low-capital implementation.*

Keywords *- Lean Manufacturing, Line Balancing, Operational Excellence, People-Centric Reliability, Productivity Improvement.*

1. Introduction

Task overload, a common consequence of pursuing competitive advantage, often leads to adverse physical and psychological effects in the workplace. Such conditions, characterized by excessive demands and insufficient resources, are known to diminish productivity, increase error rates, and negatively impact employee well-being (Karasek & Theorell, 1990; Schaufeli & Bakker, 2004). Within this context, a time study was conducted on a predominantly manual production line in a marine canvas company located in East Tennessee. The analysis revealed significant workload imbalances at specific stations and considerable non-value-added time in the activities of material handling, highlighting the direct relevance of these broader organizational challenges.

Operational Excellence, strongly influenced by lean manufacturing principles (Womack et al., 1991; Liker, 2004) and consistent with the vision of Industry 5.0, emphasizes the need to integrate efficiency and quality with humanization, sustainability, and value creation. This perspective has been reinforced through years of research on operational Excellence at the University of Tennessee, led by Dr. Rapinder Sawhney (Sawhney et al., 2020; Sawhney et al., 2021). The Sawhney Model brings a people-centered approach based on the key objective of sustainable operational Excellence. Its four principles stress that organizations should (i) minimize unnecessary resources and effort by strategically defining the problem, (ii) align all initiatives with measures of system growth and competitiveness, (iii) design processes that reliably enhance throughput and capacity, and (iv) sustain transformations by improving employees' quality of life. These principles encapsulate systems thinking and a critical problem-solving mindset. The main stages of the model are described in four modules: problem identification, design of performance measurement systems that link productivity with organizational results (de Toni & Tonchia, 2001), solution design, and implementation of a sustainability plan to ensure lasting effectiveness.

In this study, reliability is considered as the probability that a process will operate as intended within specific conditions and timeframes (Ebeling, 2010). The analysis focuses on Module 3 of the Sawhney Model, which develops solutions to improve lagging indicators by strengthening the reliability of key system resources: people, materials, equipment, and information.

Despite the extensive literature on Lean, Toyota Production System, and Operational Excellence, most studies concentrate on technical process optimization and cost reduction, with less emphasis on integrating human reliability and well-being into throughput improvement strategies.

Similarly, while Industry 5.0 emphasizes the human-centric paradigm, empirical studies applying people-centered reliability frameworks in small, labor-intensive, and high-mix production environments remain scarce. This gap motivates the present research.

Accordingly, this study investigates a marine canvas manufacturer facing the challenge of expanding market share without significant capital investment. The core research problem addressed is: how can a predominantly manual and variable production line enhance throughput and process stability while simultaneously reducing employee stress and improving their quality of life? By addressing this question by applying the Sawhney people-centric reliability framework, this paper contributes to bridging the gap between theory and practice, offering empirical evidence of how human-centered strategies can enable operational Excellence and worker well-being in labor-intensive manufacturing contexts.

2. Materials and Methods

2.1. Problem Statement and Background

The marine canvas company has a predominantly manual production line and works with individual customers. This model of service allows a wide variety of products, which can come in 43 varied brands and 65 distinct colors. Therefore, the main challenge of the project was how to expand the company's market share by increasing throughput with a manual and variable process while improving the employees' quality of life.

Process mapping was applied to highlight inefficiencies and identify bottlenecks within the production system (Ohno, 1988; Rother & Shook, 2003), as illustrated in Figure 1. The manufacturer has 10 production stations, starting with sales, which generates a ticket that is printed at the kit building and cutting stations.

The kits created are only used for finishing. If they have a logo, the cut pieces go to the Logo station; otherwise, they go directly to Layup, where the pieces are organized for Reinforcement. From Reinforcement, the pieces go to Serge, Binding, Hemming, and Finishing, where the covers will be inspected and packaged.

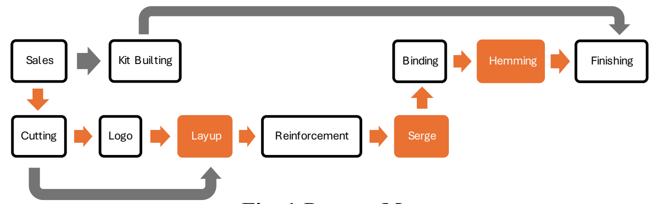

Fig. 1 Process Map

A time study was conducted to support the process line analysis, revealing the critical path and identifying bottleneck stations, highlighted in orange in Figure 1.

The longest path of the process takes 177 min (Sales – Cutting – Logo – Layup – Reinforcement – Serge – Binding – Hemming – Finishing), where Hemming, Serge, and Layup are the bottleneck stations.

Each workstation was measured ten times, which enabled the estimation of variability through Standard Deviation (SD) and Coefficient of Variation (CV), as shown in Table 1.

Table 1. Time study

Average	Mean	SD	CV
Sales	00:20:00	00:00:00	0
Kit Building	00:19:58	00:01:24	0,07
Cutting	00:13:21	00:00:44	0,05
Logo	00:15:50	00:00:55	0,06
Layup	00:21:43	00:13:55	0,64
Reinforcement	01:20:29	00:13:44	0,17
Serge	00:25:41	00:07:43	0,30
Binding	00:19:36	00:04:40	0,24
Hemming	00:31:57	00:12:30	0,39
Finishing	00:12:11	00:02:53	0,24

Due to the high coefficient of variation calculated, the critical path is categorized as stochastic. The high variation values are a consequence of the company's large portfolio, which has a business model that allows the product to be customized for the client.

2.2. Reliability Assessment Methodology

A detailed reliability assessment was conducted for the identified bottleneck stations to develop a robust solution proposal.

This approach meticulously aims to comprehensively understand which of the four fundamental pillars - People, Materials, Equipment, and Information - require targeted intervention.

By understanding where elements of the system may be failing, the solution can be optimized in a more targeted and effective way, aiming to strengthen the underlying pillars that support the process, increasing process reliability.

The reliability for each pillar was calculated by multiplying specific reliability factors, each ranging from 0 to 1 (where 1 represents 100% reliability, indicating no chance of failure or deviation). This multiplication yielded the overall reliability score for each pillar at the bottleneck stations.

For the People pillar, reliability was determined by considering three key factors: absenteeism, turnover, and stress. Absenteeism was assessed by the inverse of the employee absence rate, while turnover reflected the percentage of employees who left the company over a defined period. Stress levels were derived from an employee well-being survey conducted in July 2024, utilizing the NIOSH (National Institute for Occupational Safety & Health) methodology, with results normalized to indicate the absence of reported stress.

The Materials pillar's reliability incorporated data on repairs carried out on the production line, reflecting material quality issues, and the variability in cycle time (based on the time study presented in Table 1), which indicated consistency in material handling and processing.

This included planned and unplanned maintenance events and reports of equipment breakdowns.

Finally, Information reliability was assessed through data on Return Merchandise Authorizations (RMA) and rework incidents. RMA figures typically reflect issues stemming from inaccurate initial specifications or order processing, while rework rates often indicate errors caused by misinformation or a lack of clear instructions within the production flow.

Therefore, the reliability of the bottlenecks was calculated using the following equations:

$$R_{People} = R_{Absenteeism} * R_{Turnover} * R_{Stress} \quad (1)$$

$$R_{Material} = R_{Repair} * R_{Cycle\ Time} \quad (2)$$

$$R_{Equipament} = R_{Maintenence} * R_{Failure} \quad (3)$$

$$R_{Information} = R_{RMA} * R_{Rework} \quad (4)$$

$$R_{Bottleneck} = R_{People} * R_{Material} * R_{Equipament} * R_{Information} \quad (5)$$

The application of these formulas and the resulting data are shown in Figures 2, 3, and 4:

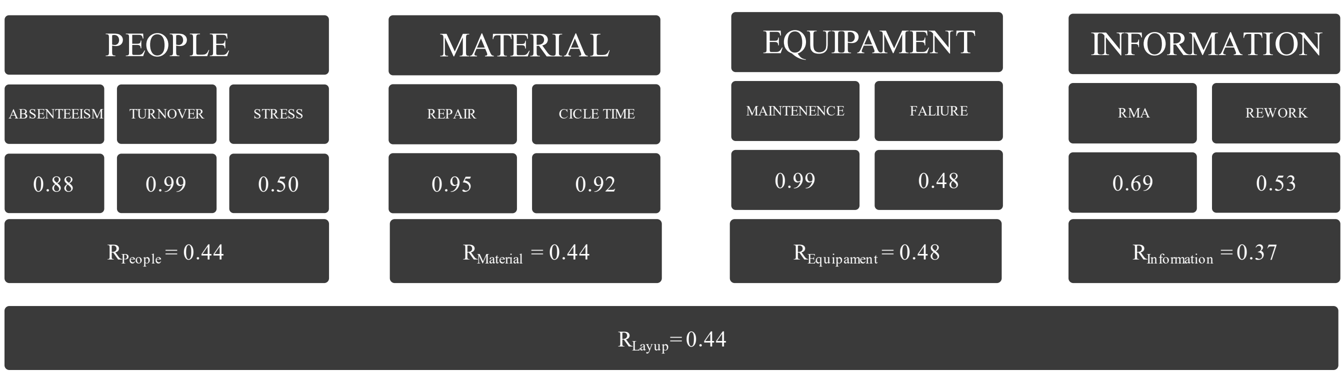

Fig. 2 Layup reliability

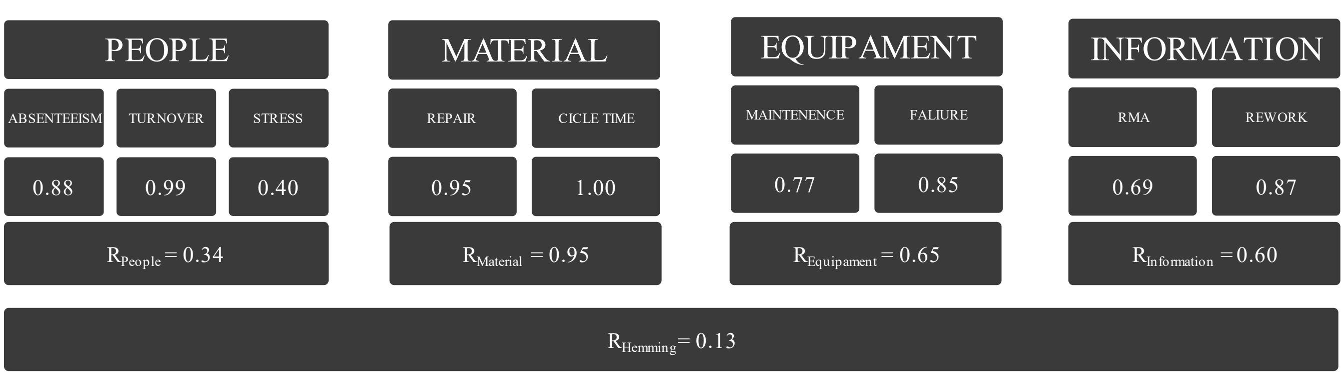

Fig. 3 Hemming reliability

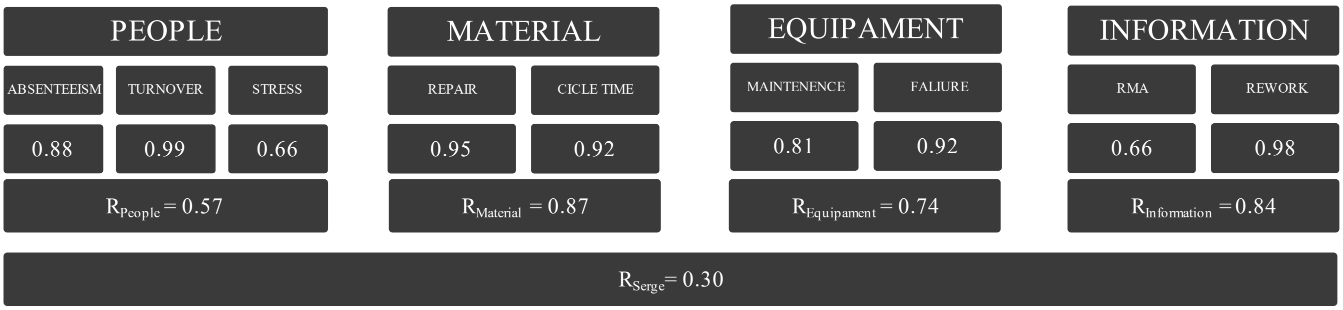

Fig. 4 Serge reliability

Based on this analysis, people and information were identified as the resources with the lowest reliability on average. Therefore, the solution strategy should concentrate on these two components with an approach geared towards worker well-being, following the application of the Sawhney Model that proposes improving the throughput of a system by providing reliability in a manner that enhances the quality of life of the employees.

3. Results and Discussion

Two solutions were proposed to tackle the previously addressed challenge: a better balance of the production line and a central strategy for improving flow and efficiency in operations management (Monden, 2011; Slack et al., 2016). The first strategy consisted of reallocating people with no investments required. By using the Yamazumi Chart (Figure 5), a clear visual representation of process cycle times is obtained, facilitating the identification of imbalances and opportunities for continuous improvement, or Kaizen (Imai, 1997; Bicheno & Holweg, 2016).

The initial line has the capacity to produce 16 marine canvas covers a day (takt time = 32 minutes). Furthermore, there is a high non-added value time and multitasking people, causing an elevated level of stress at work and a low throughput. Therefore, the line balancing aims to achieve the mark of 42 products a day by reducing takt time and improving employees' quality of life with a reliable process.

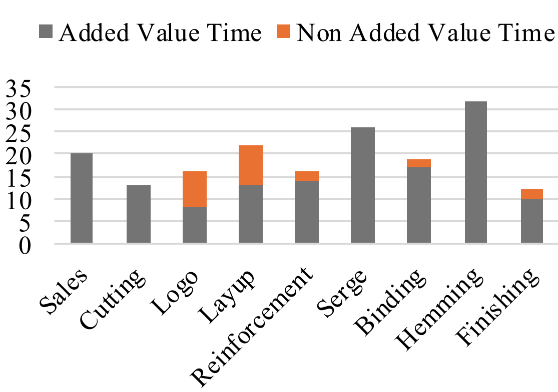

Fig. 5 Initial Line Process – Yamazumi Chart

3.1. Solution 1 – Line Balancing with No Investments Required

Regarding Layup, two people are working at that station and as material handlers simultaneously. It leads to low reliability due to the stress that multitasking and non-added-value time causes in people. For this case, the proposed solution is to keep only one employee at the station and dedicate the other to be the material handler.

From the perspective of Serge and Hemming, there is only one person working on each station, which involves the longest cycle time. Given this scenario, Figure 6 illustrates a viable strategy the company could consider: relocate people from stations such as Kit Building and Finishing to sewing and hemming.

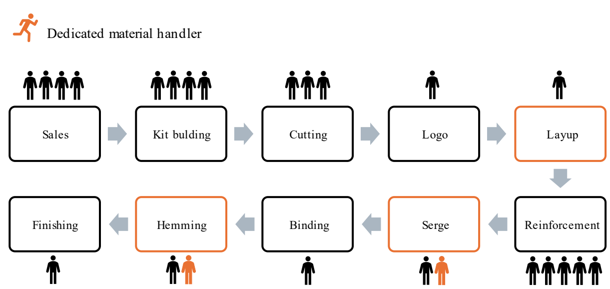

Fig. 6 Illustration of relocating people

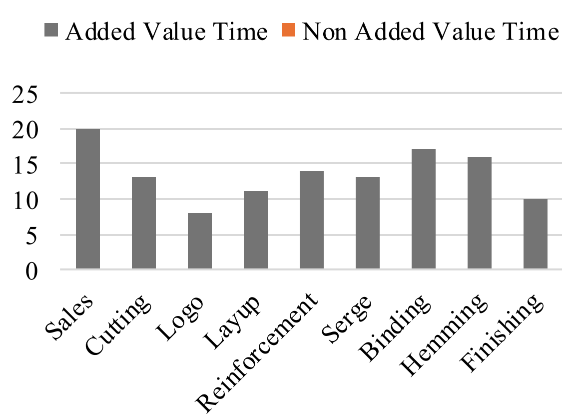

Fig. 7 Solution 1 Line Process – Yamazumi Chart

By applying this no-investment-required solution, the company could achieve a more linear distribution of the process with a lower takt time of 20 minutes, allowing for an increase in throughput to 25 marine canvas covers a day, as shown in Figure 7.

3.2. Solution 2 – Complementary Line Balancing with Investments Required

Despite the remarkable results estimated from applying the first solution, the production line still had the potential for improvement. Figure 8 presents the complementary strategy proposed, which involves introducing two additional resources for the production line. The first would work on Reinforcement, and the second would split their time between biding and hemming because those are close and similar stations. Regarding sales, which will be the last bottleneck after hiring, the proposal is to include a shopping cart feature on the company's website where the customer could choose all the preliminary information instead of doing the whole process by phone or e-mail. It will optimize customer service at the sales station.

In addition, the reliability of information at all stations is low due to the rework generated and the lack of prompt communication regarding changes or cancellations of orders. As a complementary solution, the use of an Andon system is proposed, a key tool from the Toyota Production System that enables real-time communication and immediate problem-solving on the production line (Shingo, 1989). It facilitates real-time communication and immediate problem-solving, supporting Lean continuous improvement and waste reduction principles.

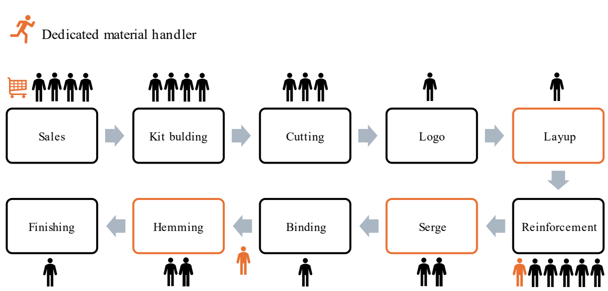

Fig. 8 Illustration of hiring people, which includes a shopping cart feature on the company's website

By implementing those improvements, a production scenario of 42 products per day is estimated based on the theoretical takt time of 13 minutes reached as shown in Figure 9.

Beyond increasing throughput by approximately 162% (from 16 to 42 units per day) and consequently boosting the company's revenue, the proposed solution is expected to improve employees' quality of life by establishing a more reliable process and reducing workplace stress.

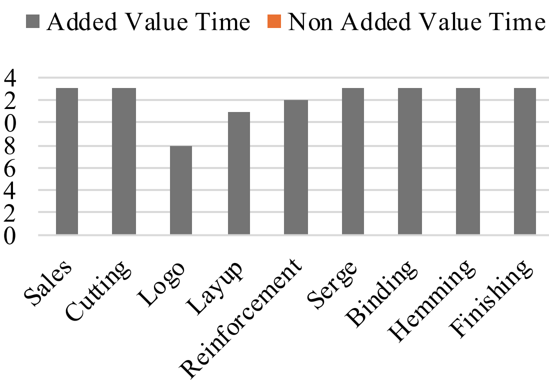

Fig. 9 Solution 2 Line Process - Yamazumi Chart

4. Conclusion

This study demonstrated the practical application of the Sawhney model—a people-centric framework—in a project aimed at simultaneously increasing productivity and enhancing employee quality of life. A detailed time study of the production line enabled the identification of non-value-added activities and inefficiencies at specific workstations. By applying reliability analysis across the four key resource dimensions (people, materials, equipment, and information), bottlenecks were identified and addressed through targeted interventions designed to increase value-added time and process stability. Notably, the pillars of people and information exhibited the lowest reliability across all bottleneck stations, reinforcing the need for human-centered strategies.

Two distinct line balancing strategies were proposed to address these challenges. The first required no financial investment and involved reallocating personnel between stations. The second entailed additional investment, including the hiring of two new workers. Both approaches significantly increased throughput, a more balanced workload, reduced operational stress, and improved overall process reliability.

The results of this study demonstrate that incorporating people-centric reliability factors (stress, absenteeism, turnover) yields greater improvements in both throughput and employee well-being. Specifically, the productivity increase of 162% surpasses the incremental improvements (typically 20–40%) reported in similar high-mix manual production environments (e.g., Sila & Ebrahimpour, 2003). This indicates that integrating human reliability into line balancing provides a competitive advantage compared to state-of-the-art Lean approaches.

In conclusion, the integration of Lean Enterprise principles with a people-centric operational model, as exemplified by the Sawhney framework, offers a powerful and sustainable path toward operational Excellence

(Nightingale & Srinivasan, 2011). The findings suggest that prioritizing employee well-being is an ethical responsibility and a strategic lever for long-term productivity improvements, echoing the evolution of lean thinking (Hines et al., 2004).

Acknowledgment

Authors 1, 2 and 3 contributed equally to this work.

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