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Feasibility Analysis of Lean Manufacturing for the Apparel Industry

Fernando T.T.D., Perera K.A.S., Ratnayake V.S.
Department of Textile and Clothing Technology
Faculty of Engineering, University of Moratuwa
Katubedda, Moratuwa
SRI LANKA

Abstract: Lean manufacturing is a popular technique utilized by various modern manufacturing industries to harness the vast benefits it yields. The main intention of adopting a lean culture is to eliminate non-value adding activities from the production process through small incremental changes in order to achieve the desired quality, on time delivery and cost reduction. Apparel industry, being a rapidly evolving manufacturer, has also incorporated lean tools to their core business functions to obtain the vast array of benefits it renders. However, only a small minority of apparel manufacturers have managed to obtain the full potential benefits of lean philosophy. This research is conducted to evaluate such scenarios in order to streamline the barriers encountered by apparel manufacturers during the implementation and post-implementation stages of lean manufacturing. Further, it is aimed at developing feasible solutions to overcome such barriers and to validate the results.

Keywords: Apparel, Barriers, Implementation, Lean Manufacturing, Total Productive Maintenance

I. Introduction

Modern manufacturing companies have successfully integrated lean philosophies into their core business functions to obtain the vast array of benefits it renders [1]. As a result, lean manufacturing has evolved itself from a philosophy to a more critical success factor for modern businesses to ensure business continuity and achievement of intended performance targets [2]. Lean concepts have managed to continuously deliver high quality, on time delivery and value for money for “Toyota” throughout the past 4 decades [3]. However, majority of manufacturing companies have failed their lean journey either in implementation stage [4] or post implementation stage [5]. Apparel industry, being a pioneer in manufacturing arena, has also adopted lean concepts with few alterations to achieve the intended customer requirements [6]. However, as per [7], majority of apparel manufacturers have failed in implementing and sustaining lean concepts and transformed themselves back to the traditional manufacturing methods even after incurring massive costs on adopting a lean culture. This arises the need to identify the reasons behind those failures. Therefore, this research was conducted to analyse such scenarios to identify the barriers encountered by the management during lean implementation and post-implementation stages and to provide feasible solutions pertaining to such barriers.

II. Research Objectives

- Identify key barriers to the implementation and the sustainability of lean manufacturing in the apparel industry.
- Formulate feasible solutions to overcome those barriers.
- Validate developed solutions through industry feedback.

III. Methodology & Results

A. Identify key barriers to the implementation and the sustainability of lean manufacturing in the apparel industry

1) Problem Identification

A comprehensive literature review was conducted to identify the practical viability of lean concepts in the manufacturing arena. The main focus area was the famous “Toyota Production System” and its derivatives. Then, an in-detailed analysis was carried out targeting the apparel manufacturers who have adopted lean principals to their business models. In addition to that, case studies and published articles on lean failures and barriers were analyzed to identify the link between lean failures and apparel manufacturing,

2) Data Collection through Pre-questionnaire

Explanatory mixed method was used to develop a pre-questionnaire with different sections to collect both quantitative and qualitative information. Qualitative information such as reasons for labour turnover & absenteeism after lean implementation, reasons for failures under different lean tools, comments of the lean practitioners etc. were collected to strengthen the results of the quantitative information.

Based on the industry feedback, questions under 6 lean tools [5-S, Total Productive Maintenance, Standardization, Quick Change Over, Kanban/Pull System and Kaizen] were included in the quantitative section of the pre-questionnaire. A Likert Scale of 1-5 was used to collect the required quantitative information.

This questionnaire was distributed among lean practitioners through email attachments, interviews and through post.

3) Sample Selection

Samples were taken with equal representation from all the major segments of apparel manufacturers [Intimates, Sportswear, Casualwear and Swimwear]. The pre-questionnaire was distributed to 300 lean practitioners in the apparel industry. As per [8], the sample distribution of the mean can be safely assumed to be normal if the sample size is greater than 30. In other words, if the sample size is greater than 30, the central limit theorem can be applied [9]. Therefore, a sample size of 300 can be considered as a valid sample to obtain information to facilitate the research.

4) Prioritization of Data

Reference [10] indicates “Relative Importance Index (RII)” as a commonly used prioritization method. Therefore, RII was used to prioritize the data collected under 6 key lean tools based on the number of responses and their ratings. The 1-5 ratings in the questionnaire was converted into 1-100 rating using the RII formula.

$$\text{Relative Importance Index} = \frac{R_{i1} * 0.2 + R_{i2} * 0.4 + R_{i3} * 0.6 + R_{i4} * 0.8 + R_{i5} * 1}{R_{i1} + R_{i2} + R_{i3} + R_{i4} + R_{i5}}$$

RI_i = Relative Importance Index for the *i*th issue

R_{i1} = Number of responses for “Very Low”

R_{i2} = Number of responses for “Low”

R_{i3} = Number of responses for “Average”

R_{i4} = Number of responses for High”

R_{i5} = Number of responses for “Very High”

The positivity and the negativity of the questions were also considered when allocating the scale value in final calculations. i.e. “Very High” response for “Knowledge and understanding about lean concepts” was considered as a non-barrier whereas “Very High” response for “Level of employee resistance” is taken as a barrier.

The final rating of a lean tool was considered as the simple average value of the individual RII values of the questions under that lean tool.

Results of the pre-questionnaire (based on 284 responses received) are indicated in the Table 1.

TABLE 1: Pre-questionnaire Results (based on RII)

Lean Tool	Relative Importance Index	Rank
5-S	0.623	2
Total Productive Maintenance	0.678	1
Standardization	0.517	4
Quick Change Over	0.504	6
Kanban/ Pull System	0.611	3
Kaizen	0.514	5

Total Productive Maintenance, 5-S and Kanban were selected as the lean tools which have the most impact on implementation and sustainability based on the above results.

5) Data collection through ‘Questionnaire on selected lean tools’.

Another questionnaire was developed and distributed among the previous sample after validating with the industry. The main focus of this questionnaire was to highlight the underlying reasons behind the failures of TPM, 5-S and Kanban in the apparel industry.

6) *Prioritization of Data – Questionnaire on selected lean tools*

The statistical method of RII was used to prioritize the responses obtained from the second questionnaire. The following reasons were selected to further analysis.

Table 2: Results of the Questionnaire on Selected LeAn Tools

Issue	Tool	RII
Level of attention given to easy maintenance & repair possibilities when procuring new machinery	TPM	0.829
Level of involvement of employees in planning new machinery for Production Divisions	TPM	0.747
Level to which failures are evaluated and corrected	TPM	0.735
The extent to which employees follow 5S principles on their own	5S	0.729
Level to which new employees are trained on the current TPM system	TPM	0.712
Level to which responsibilities are defined for maintenance for the employees of the Production Division	TPM	0.706
Ability of maintenance & repair planning system to detect disorder	TPM	0.671
Level of condition analysis for critical construction parts	TPM	0.647
Level of involvement of executives in planning new machinery	TPM	0.635
Level of involvement of maintenance in planning new machinery	TPM	0.606
Level to which failures are documented	TPM	0.594

B. Formulation of feasible solutions to overcome lean barriers.

The following solutions were developed to the issues identified above using the available literature and the qualitative feedback obtained during the data collection process.

1) *Lack of adherence to 5-S principals by the employees on their own.*

The negligence of the employees in continuously maintaining 5-S methodology in their routine operations has been identified as a major issue related to the sustainability of lean principals. Even though the 5S principals have been applied through external consultants and the top management, the employees at the lower levels of the organizational hierarchy are not willing to adhere to the set standards resulting poor lean implementation.

Solution: Structured continuous training programmes could be conducted to the employees at all levels in the organizational hierarchy to eliminate this issue to a certain extent [11]. The programmes should be delivered in a manner to ensure the active participation of the employees [12] without making it a typical lecture based training. Top management should drive this process by incorporating a lean culture through motivation and continuous mentoring. Frequent 5-S audits should be conducted along with an incentive schemes to benefit the employees who have scored higher marks [13]. Best employees should be highlighted and recognition should be given on a monthly basis to inculcate a performance driven culture [14]. The monetary benefits given through these incentive schemes could act as a major trigger to drive employees towards adapting to a 5-S culture.

2) *Lack of comprehensive failure evaluation & correction procedure.*

It was evident from the questionnaires that most of the apparel manufacturers do not document the failures in a standardized manner. Instead they are trying to give instantaneous solutions to rectify defects. Further, due to the less documentation, the ability of the companies to develop proper failure evaluation methods such as ‘Failure Mode Effects Analysis’ are restricted.

Solution: As an initial step, a failure documentation team should be developed preferably from the production members. This process should be incorporated into the routine tasks of the employees to record information such as type of failure, type of machine, downtime, operator etc. Reference [15] suggests to formulate a cross functional team to analyze the recorded failures due to the diversified knowledge they possess. This could facilitate a proper root cause analysis followed by a comprehensive database creation [16] regarding failures encountered and solutions taken. The information of the database can be utilized to solve similar future problems.

3) *Lower attention given to easy maintenance & repair possibilities when procuring new machinery.*

Proper machine maintenance procedure is highly essential to ensure less defects. Therefore, investments have to be made for high quality equipment and machine maintenance to reduce downtime [17]. However, the results of the questionnaires indicate that the level of attention given to the areas such as machine maintenance and repair possibilities during the machine procurement process was not adequate. In addition to that, the input from the lower level employees regarding the machine requirements were not considered during the procurement process which could have resulted the excessive machine breakdowns.

Solution: A comprehensive feasibility analysis has to be carried out along with a quality audit with regards to each and every machinery being purchased [18]. As per [19], lesser probabilities for machine breakdowns & repairs, ability to repair using existing tools and the in house knowledge regarding the machine repairs

have to be considered prior to making an investment decision. Due to the operational knowledge of the machine maintenance teams, it is advised to incorporate their ideas in selecting the appropriate machineries [20].

4) *Provision of inadequate training to new employees regarding the existing TPM system.*

Inadequate knowledge and understanding of TPM was identified as a key barrier to sustain lean manufacturing in the apparel industry.

Solution: Training programmes should be conducted for the employees at all levels in the organizational hierarchy covering the entire TPM process [21]. As an initial step, an off-the-job training can be provided to the employees under a simulated work environment covering basic TPM principles. Then an on-the-job training could be provided along with an individual mentor to explain the core principles of TPM and its practical applicability.

5) *Lack of clarity in allocating maintenance responsibilities to the production employees.*

The autonomous maintenance which is a key concept in TPM is not properly utilized in the apparel industry. The qualitative aspect in the questionnaire indicates that the unawareness of the employees regarding the individual responsibilities to follow TPM could be a major issue to the failure of lean manufacturing in the apparel industry.

Solution: All the production level employees should be trained to repair small frequent machine breakdowns [22]. Further, they should be given the responsibility to clean their machines and maintaining them in good working conditions. The production employees should only seek the assistance of maintenance team if they encounter a major machine breakdown which is beyond their scope.

6) *Insufficient knowledge of the maintenance & repair system to detect disorder in advance.*

As per the results obtained from the questionnaire, it is evident that the existing system does not have sufficient knowledge to detect disorders in advance. This issue could be directly related to the lack of knowledge of the production employees regarding the machines and their critical parts which could lead to the frequent machine breakdowns. Thus the possibility to detect disorder is not possible in advance due to the lack of knowledge.

Solution: Prior machine disorder identification could be introduced to the production employees through a structured training programme on machine maintenance [23]. Higher attention should be given to the critical parts in machines and daily checkups should be followed. In addition to that, routine repair & maintenance procedure should be conducted by the maintenance team to eliminate the occurrence of major machine issues [24].

C. Validate developed solutions through industry feedback

The solutions to the research problem were developed based on the available literature and the ideas of the research group through the experience. Therefore, due to the questionability of the above mentioned solutions in the apparel industry, another questionnaire was developed and circulated among the same sample as the previous questionnaires. The Table 3 indicates the responses obtained from the industry with respect to the validity of the solutions.

Table 3: Results of the Validation Questionnaire

No	Issue	Solution	Feasibility
1	Lack of adherence to 5-S principals by the employees on their own.	Structured continuous training programme on 5S	Feasible
		Motivation through incentives, Sense of Ownership, Employee of the month	Feasible
2	Lack of comprehensive failure evaluation & correction procedure.	Build a cross functional team	Feasible
		Document the failures	Feasible
		Brainstorming sessions	Feasible
3	Lower attention given to easy maintenance & repair possibilities when procuring new machinery	Feasibility analysis before procurement	Feasible
		Involvement of Production & Maintenance employees	Feasible
4	Provision of inadequate training to new employees regarding the existing TPM system.	Initial off the job training	Not feasible
		On the job training via mentoring and active participation	Feasible
5	Lack of clarity in allocating maintenance responsibilities to the production employees.	Define responsibilities for cleaning & maintenance	Feasible

		Training on autonomous maintenance	Feasible
6	Insufficient knowledge of the maintenance & repair system to detect disorder in advance.	Assign responsibilities to the production teams	Not feasible
		Develop & maintain a standardized routine maintenance procedure	Feasible

IV. Conclusion

The results of the pre-questionnaire indicates that the lean tools “Total Productive Maintenance, 5-S and Kanban” are the tools which have the most impact on the implementation and the sustainability of lean manufacturing in the apparel industry. As per the further analysis on the above lean tools it was identified that the level of knowledge and the involvement of the lower level employees were not sufficient as compared to the philosophical requirement of the lean manufacturing. Industry feedback suggests that these issues could be easily eliminated through the provision of structured continuous training programmes targeted at the employees. The continuous adherence to the lean tools by the employees should be evaluated and continuous mentoring should be provided to ensure the long term sustainability of lean manufacturing in the apparel industry.

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