Process enhancement in a wet grinder manufacturing company through lean implementation framework – a case study

K. Sivananda Devi*

Department of Mechanical Engineering,
PSG Institute of Technology and Applied Research,
Coimbatore, India
Email: ksd@psgitech.ac.in
*Corresponding author

V. Raja Sreedharan

Department of Management,
Amrita Vishwa Vidyapeetham,
Kochi Campus, Kerala, India
Email: rajasreedharan@hotmail.com

S.R. Devadasan

Department of Production Engineering,
PSG College of Technology,
Coimbatore, India
Email: devadasan_srd@yahoo.com

Abstract: During the past two decades, lean production (LP) has been finding wide adoption for improving the processes. Despite its widespread adoption, LP is yet to find application in household appliances manufacturing industry. In order to overcome this deficiency partially, the research reported in this paper was carried out. This research was carried out in two phases. In the first phase, a model called conceptualisation lean implementation (CLIM) phase, inculcating, monitoring and controlling, manufacturing system transformation was designed to implement LP in wet grinder manufacturing industry. During the second phase, an investigation was conducted to examine the effect of implementing LP through CLIM model in wet grinder manufacturing industry. The outcome of this research indicated that CLIM model acts as a vehicle to successfully implement LP in wet grinder manufacturing industry. After reporting these activities, this paper is concluded with suggestions to conduct many more such investigations on implementing CLIM.

Keywords: value stream mapping; lean production; 5S; takt time; current state map; cycle time; productivity.

Reference to this paper should be made as follows: Devi, K.S., Sreedharan, V.R. and Devadasan, S.R. (2020) 'Process enhancement in a wet grinder manufacturing company through lean implementation framework – a case study', *Int. J. Business Excellence*, Vol. 22, No. 1, pp.33–51.

Biographical notes: K. Sivananda Devi is a Faculty from the Department of Mechanical Engineering, PSG Institute of Technology and Applied Research, Coimbatore, India. She received her Doctorate in Mechanical Engineering and ME with distinction in Product Design and Development from the Anna University, Chennai. She received her BE with distinction and Best Outgoing Student Award in Production Engineering from the PSG College of Technology, Coimbatore in 1993. She has 15 years of professional experience in research and development of various industries like Larsen and Toubro, Mumbai, India, TVS Sundaram Clayton, Chennai, India, Hindustan Motors, Hosur, India. She has more than nine years of experience in teaching. Her research interest includes manufacturing practices and performances, manufacturing strategy, quality function deployment and additive manufacturing. She has published several works in refereed international journals and refereed international conferences proceedings.

V. Raja Sreedharan is an Assistant Professor from the Department of Management Studies, Amrita School of Business, Kochi Campus. He attended international conferences and published many articles on Lean Six Sigma, MCDM approach, and structural equation modelling in peer reviewed journals. His current research interests are centred in the field of Lean Six Sigma for services, quality management in healthcare, circular economy and Industrial 4.0. He serves as an active consultant to the public and private sectors.

S.R. Devadasan is a Professor from the Department of Production Engineering at the PSG College of Technology, Coimbatore, Tamil Nadu, India. He has six months of industry experience and more than 25 years of teaching and research experience. He has published over 200 papers in the proceedings of the leading national and international conferences. He has published over 120 research papers in international journals. He first authored a book titled *Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities*, which was published by Prentice Hall of India (PHI) Private Limited, New Delhi, India in 2012. His areas of research interest include six sigma, agile manufacturing, lean manufacturing and total quality management.

1 Introduction

Lean production (LP) principles are increasingly being implemented in manufacturing companies to reduce cycle time and to improve manufacturing productivity, quality and customer satisfaction (Seth et al., 2017; Jasti and Kodali, 2016). Increased competition and requirement to meet higher quality standards have been forcing modern companies to adopt LP principles for increasing the efficiency of the manufacturing processes (Goncalves and Salonitis, 2017; Porter and Lee, 2013). The efficiency of the manufacturing processes is improved through the implementation of LP principles by eliminating seven wastes namely motion, waiting time, overproduction, over-processing, defect, inventory and transportation, and reducing the variability of the internal resources and processes (Nadeem et al., 2017; Anvari et al., 2011; Shah et al., 2008). Numerous research papers report the LP benefits obtained by many industries and their application in various types of industries. Yet such benefits are yet to be nourished by supplementing LP in home appliances manufacturing industry. On realising this gap, the research reported in this paper was carried out. This research was conducted to investigate the implementation of LP in the wet grinder manufacturing industry. Wet grinder finds wide adoption in Indian hotels and households. Food products like *idly*, *dosa* and *vada* are prepared from batter by wet grinding food grains. Wet grinder is the most popular kitchen appliance used to make the batter by grinding. The contemporary wet grinder manufacturers practice conventional and non-scientific manufacturing practices (Holweg, 2007). The problems persisting in the wet grinder manufacturing companies are less productivity, high costs of manufacturing and high throughput time. The application of LP principles in wet grinder manufacturing companies has not been fully explored. Papers reporting the implementation of LP principles in wet grinder manufacturing companies are found to be very less. Hence it is essential to implement new innovative approaches and techniques, and manufacturing system in order to improve the performance level of the wet grinder manufacturing companies. Manufacturing system models like Toyota Production Systems (TPS) and LP are highly suitable for implementation in scientifically managed large-sized organisations (Antony et al., 2005; Kureshi et al., 2010). On the other hand, LP in wet grinder manufacturing companies which are small and medium-sized is going to be challenging as the production environment prevailing in those companies are not compatible for immediate implementation of models that are used for implementing LP in large-sized companies (Temtime et al., 2003; Thomas et al., 2009; Gnanaraj et al., 2010; Malik and Nilakant, 2011). A survey conducted in the literature arena indicated that LP principles work well when exclusive models for implementing them in specific industries are adopted. This inference indicated that an exclusive model for applying LP in wet grinder manufacturing industry is the need of the hour. This need has been fulfilled by carrying out the research work being reported briefly in this paper. This research work was carried out in two phases. During the first phase, a model called conceptualisation, lean implementation phase, inculcating, monitoring and controlling, manufacturing system transformation (CLIM) was designed. During the second phase, the application of LP in the manufacturing of wet grinders was investigated by implementing the steps of the CLIM model. These activities are reported in the following sections of this paper. In the next section, literature reviews conducted before beginning the research work is reported. In the subsequent sections, the two phases of this research work are reported. In the last section, the paper is concluded by implementing the framework.

2 Literature review

Given the scope of the research work being reported here, the literature was reviewed to trace the application of LP in the household product industry and identifying the LP implementation models that are used in real time scenario. The details of conducting this literature review are presented in the subsequent two sub-sections.

2.1 LP in the household product industry

A reference to the Standard Industrial Classification (SIC) maintained by the USA Government revealed the existence of 20 manufacturing sectors. As mentioned in the previous sections, LP researches have been prominent in automobile, aerospace and electronic manufacturing sectors. However, LP research dealing with household products is scarcely reported in the literature arena. VSM is used to depict the value added and non-value added activities in the wet grinder assembly line. The benefits achieved were reduced assembly lead time by 23%. The researchers have done future state map (FSM) to meet the increase in customer demand (Devi et al., 2018). LP implementation was carried out in thermoformed refrigerator liners by utilising the failure mode and effect analysis (FMEA) and prioritising the critical defects that lead to heavy losses like man, material, money, time and machines. For implementing the cost-effective solutions analysing and effective management of these resources are of prime importance (Chowdhury et al., 2014). LP was adopted in sewing machine manufacturing line by employing VSM technique to identify the wastes. Moreover, the application of lean techniques like line balancing, quality-at-the-source and layout redesign resulted in the reduction of 96% production wastes and 43% lead time (Obeidat et al., 2014). LP principles reduced the mean and variance of the production time of amplifiers using first in first out control flow process layout (Maneechote and Luangpaiboon, 2010). LP concepts were implemented in the manufacturing line of washing machines by sizing the amount of 'Kanban integration'. In the next stage, the progress of production flow was simulated using ARENA for studying the improvements of the business performances and achieving flexibility (Romano et al., 2009). LP paradigm like the continuous flow and mixed levelling was implemented in the water heaters manufacturing industry to optimise the design of the shop floor layout (Serrano et al., 2008). The results of the literature review presented above have indicated that some of the most commonly used household products like air-conditioners, compressors, generators and wet grinders have not been covered by LP research and practices. It is to be noted that the uncovered products listed above are also to be customised in order to meet the customer expectations for carrying out the day-to-day activities (Sreedharan and Sunder, 2018). The advantages of implementing LP in these household appliance products can be examined by LP researchers. On drawing this inference, while pursuing the research work being reported here, a wet grinder was chosen as the candidate product for investigation of implementation of LP.

2.2 LP implementation models

Roadmap and frameworks are to be adopted for the most successful introduction of lean manufacturing paradigm (Mostafa et al., 2013). By reviewing the literature, the initiatives taken for lean implementation in this direction were identified and discussed in this section. LP frameworks are classified as 'design/conceptual' and 'implementation' frameworks. The design/conceptual frameworks focus on the constitution and elements of LP, while the implementation frameworks describe the sequence of activities to be taken up for LP implementation (Yusuf and Aspinwall, 2000). Such frameworks and its characteristics are described in Table 1.

Conceptual framework to carry out the green and lean assessment was developed by studying green and lean implementation in the companies. The results of this study confirmed that the initiatives considered in the conceptual framework were appropriate (Duarte and Machado, 2017; Sreedharan et al., 2018). LP framework was developed by conducting critical and comparative analyses on the existing frameworks. The results of these analyses indicated that the majority of frameworks have been developed based on novelty concept. Furthermore, 11 pillars were identified with the help of comparative analysis and proposed a framework with the help of these 11 pillars and 83 elements

(Jasti and Kodali, 2016). A framework for effecting sustainable lean implementation was developed using interpretive structural modelling approach based on the identification of eight significant lean practice bundles in literature arena. It was emphasised that the order of execution of lean practice bundles and understanding the interrelationship between these practice bundles were very important (Jadhav et al., 2014). A conceptual framework to overcome some of the deficiencies like the absence of a structured framework for implementing lean initiatives, managing lean implementation process and poor understanding of the lean concept were developed. However, this framework requires to be validated after implementation (Mostafa et al., 2013).

Table 1 LP frameworks presented in literature arena

S. no.	*Authors*	*Nature of the framework*
1	Duarte and Machado (2017)	Framework for green and lean implementation in automotive industry
2	Jasti and Kodali (2016)	Framework for lean production system: an integrative approach
3	Jadhav et al. (2014)	Framework for sustainable lean implementation: an Interpretative structural modelling approach
4	Mostafa et al. (2013)	Conceptual framework for lean implementation containing the success factors
5	Karim and Arif-Uz-Zaman (2013)	Effective framework for implementing lean manufacturing strategies
6	Rose et al. (2010)	Conceptual framework for lean implementation in SMEs
7	Anand and Kodali (2010)	Conceptual framework which consisted of 65 lean practices
8	Motwani (2003)	Theoretical framework based on business process change
9	Womack and Jones (2003)	Framework for lean definition and implementation steps
10	Ahlstrom (1998)	Framework for sequencing the lean production principles in the implementation process
11	Smeds (1994)	Generic framework for managing changes towards lean enterprise

A methodology was proposed to identify the wastes, the relevant performance indicators and the appropriate lean tools for achieving the performance improvement and establishing the lean culture in the organisation. It was mentioned that the continuous performance measurement metrics in terms of efficiency and effectiveness are proved to be appropriate methods for evaluating lean performance. However, the effectiveness of this method has to be demonstrated by applying it in a real-time assembly process (Karim and Arif-Uz-Zaman, 2013). LP is concerned with manufacturing department as well as with the entire enterprise. LP implementation should start with involving design, manufacturing, marketing, distribution, accounting, and field service. Such implementation will result in improved flexibility and reduction in manufacturing lead time. In addition to this, the lean enterprise also needs to be incorporated with appropriate policies, measures, service initiatives and logistics (Womack and Jones, 2003). The experience of carrying out the case study revealed that lean manufacturing has to be implemented as an innovation process. The new systems that emerged due to the implementation of LP were both successful and economical (Smeds, 1994). It was found that researchers have emphasised the need for developing exclusive models for implementing LP principles in specific industries.

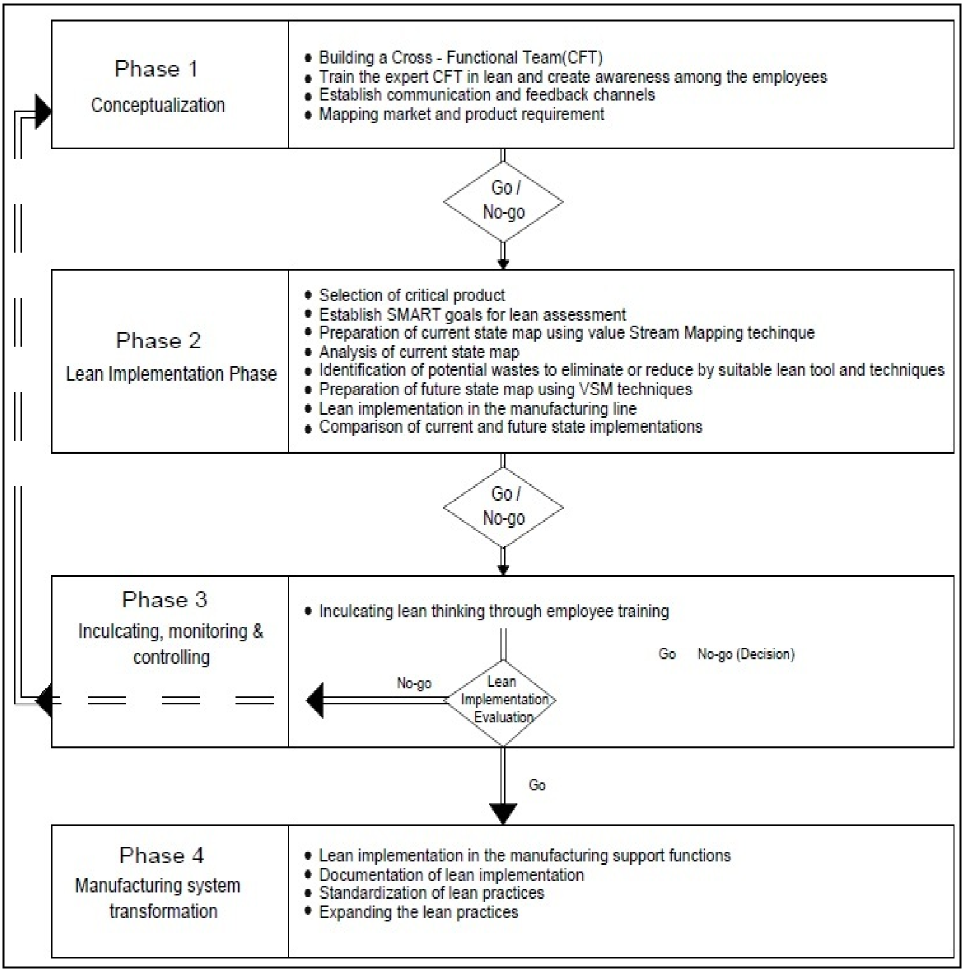
It was found that LP has been adopted across numerous industrial sectors worldwide. This inference was also supported by Panizzolo et al. (2012). However, many industries have not obtained the desired results due to inadequate knowledge about LP by both the employer and the employees of the company. In India, the household product industry has been growing significantly since liberalisation and is recognised as an important sector that contributes towards the economic development of the country. A careful study revealed that LP cannot be applied successfully in wet grinder manufacturing companies by employing these models. These models do not account for integrating company goals with lean thinking and overcoming the implementation failure prevailing in wet grinder manufacturing companies. As an effort to fill this research and implementation gap, the CLIM model has been contributed through the conduct of the research work and its implementation is being reported in this paper.

3 CLIM model

In order to face the challenges and avoid subsequent failures during LP implementation, lean implementation model (CLIM) was designed. The CLIM model has been designed to facilitate the implementation of LP in contemporary wet grinder manufacturing industry in a phased manner. The first phase has been designed to conceptualise in implementing lean thinking and establishing SMART goals to meet the customer expectation by building the lean expert team. The second phase has been designed to plan the LP implementation by mapping the product and market requirement and map the future state from the current state map. In the second phase execution of the FSM in the selected assembly line was also carried out followed by a comparison of current and future states. The third phase has been designed to train the employees while implementing LP in the selected assembly line, develop the procedures for implementing LP. After implementation, the results are required to be monitored and evaluated by referring to the SMART goals. The fourth phase has been designed to facilitate the documentation of the lessons learned and implementation of LP for continual improvement and standardisation of the practice. The implementation of LP can be expanded to other assembly lines.

As shown in Figure 1, CLIM is a sector-specific systematic model for wet grinder manufacturing company to implement LP. It facilitates scientific decision making at each level of the manufacturing system while implementing LP in wet grinder manufacturing companies. CLIM is an effective model for reducing and/or eliminating the implementation failures while establishing the LP in wet grinder manufacturing companies. CLIM model facilitates to enhance the performance of the manufacturing system by reducing and/or eliminating the NVA by focusing on customer expectations and satisfaction.

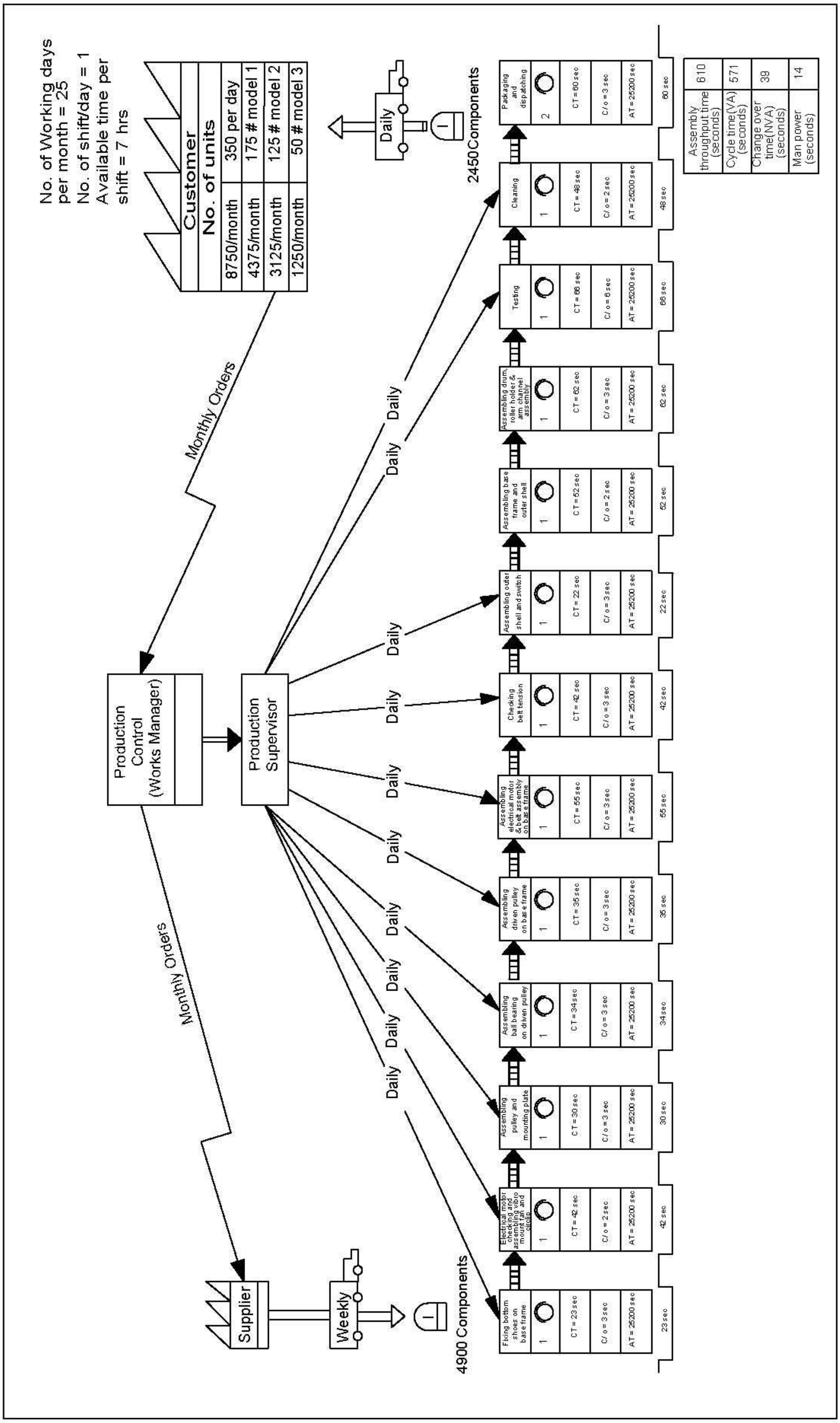
Figure 1 Implementation phases and steps of the high CLIM model



4 Case study

Based on the literature review it was found that, very few studies have explored lean in the household products sector. Therefore, taking this as motivation, the author focused on household product manufacturer for the study. The implementation of LP through CLIM model was investigated in a wet grinder manufacturing company situated in Coimbatore, India. In order to maintain anonymity, this company is referred in this paper as XYZ. XYZ is a pioneer in manufacturing wet grinders for over three decades. Wet grinders, mixer grinders and cookers are manufactured in XYZ. With organisational strength of around 100 employees, dedicated functions like research and development, manufacturing, purchasing, quality improvement, sales enhancement and market promotion are performed in XYZ.

Figure 2 Current state map of the main assembly line



4.1 Phase 1: conceptualisation

To begin with, the author of this paper presented and appraised to the vice president of XYZ about the need to implement LP for overcoming the problems faced by XYZ and the CLIM model. A lean CFT comprising managers from all the departments was formed. Data was collected for six months and the major two problems were identified. One is excessive utilisation of manpower in the assembly process and the high cost of manufacturing per unit of a wet grinder. After conducting training and awareness programs for all the operators to effectively implement CLIM model, communication and feedback channels were established. Subsequently after getting the consent of the VP the product demand data were gathered and mapped under generic, middle and premium market segments. The outcome of the first phase of the CLIM model resulted in the initialisation of implementing LP in XYZ.

4.2 Phase 2: lean implementation phase

After conducting a detailed investigation, it was found that the assembly line of XYZ is to be balanced and labour productivity needs to be improved. XYZ is operated in one eight hour shift. Before starting the investigation, the SMART goals were formulated. The SMART goal is to increase the labour productivity by 25% in the manufacturing of wet grinders by April 1, 2018, implementing LP. After developing the SMART goals, the current state map was prepared.

4.2.1 Preparation of current state map

While conducting the investigation being reported here, data were gathered from April 1, 2017 to June 30, 2017 in XYZ after observing and understanding the assembly system and interviewing the operators. This was the basic step of the CLIM model that facilitates to understand the current practices followed in the assembly line of the wet grinder manufacturing company from the perspective of implementing LP. In order to prepare the current state map, details regarding output per shift, manpower requirement, assembly line processes, cycle time and changeover time at each station, inventory, testing-time and operational hours per day from the respective departments were gathered. The operations were carried out in 13 stations at XYZ. The cycle time and change over time were recorded by observing two operators at each station to take into account the variation in operation times brought in by operator skill. The current state map of the assembly line is shown in Figure 2, 14 operators were required per shift to generate an output of 350 units of wet grinders. There is no inventory in-between the stations. The line maintained a continuous single piece flow.

4.2.2 Analysis of current state map

Analysis of current state was made by calculating takt time and labour productivity. The company is operating one shift of eight-hour duration and 25 days per month. The average number of working hours per shift is 25,200 seconds excluding lunch break of 30 minutes and two tea break of 15 minutes. The *takt* time for producing 350 units of

$$\text{Wet grinders} = \text{Available working time per shift / customer demand per day}$$
$$= 25200 \div 350 = 72 \text{ seconds per piece}$$
$$= 350 / 14 = 25 \text{ wet grinders / employee}$$

The optimum number of operators required

$$= \text{Assembly throughput time} \div \textit{takt} \text{ time}$$
$$= 610 \div 72 = 9 \text{ nos.}$$

Whereas the

$$\text{Output per shift} = \text{Available working time per shift} / \textit{takt} \text{ time}$$
$$= 25200 \div 72 = 350 \text{ units}$$

The calculated *takt* time enabled the industry to meet the customer demand of 350 units. Currently there are 14 operators in the assembly line. It was decided by the top management with the consent from the operators to prepare the FSM that can enable to produce the same number of units by employing ten operators.

4.2.3 Future state map

After careful observations, it was found that by combining and eliminating certain operations, the FSM could be prepared to improve labour utilisation and achieve labour productivity. Particularly, it was found that checking of the electrical motor and assembling vibro mount fan with circlip could be carried out in station one in which already assembling of base shoes on base frame is carried out. This change would reduce the utilisation of the service of one operator. Furthermore, it was found that assembling bearing on driven pulley could be carried out along with assembling driving pulley and mounting plate on the electrical motor. This modification would reduce the utilisation of the service of one operator. It was found that assembling driven pulley on the base frame and assembling electrical motor with the driving pulley on the base frame and connecting the drives with the belt could be carried out in two stations and checking of belt tension could be carried out in one station. Another modification proposed was that assembling driven and driving pulley with the electrical motor in one station and assembling with a belt and checking the belt tension was moved to the next station. This combination would reduce the utilisation of the service of one operator. In addition, assembling outer shell with switch and assembling it with the base frame was carried out in one station. This change would reduce the utilisation of the service of one operator. These combined operations could reduce the utilisation of the service of one operator. The proposed modifications have been depicted in the FSM which is shown in Figure 3. As shown, by affecting those modifications, the number of operators was brought down from 14 to 10. The balanced assembly line that has been modified was incorporated with nine stations by combining and eliminating certain operations.

4.2.4 Comparison of current and future state implementation

Comparison of the assembly line parameters during current and future state activities is shown in Figure 4.

Figure 3 FSM of the main assembly line

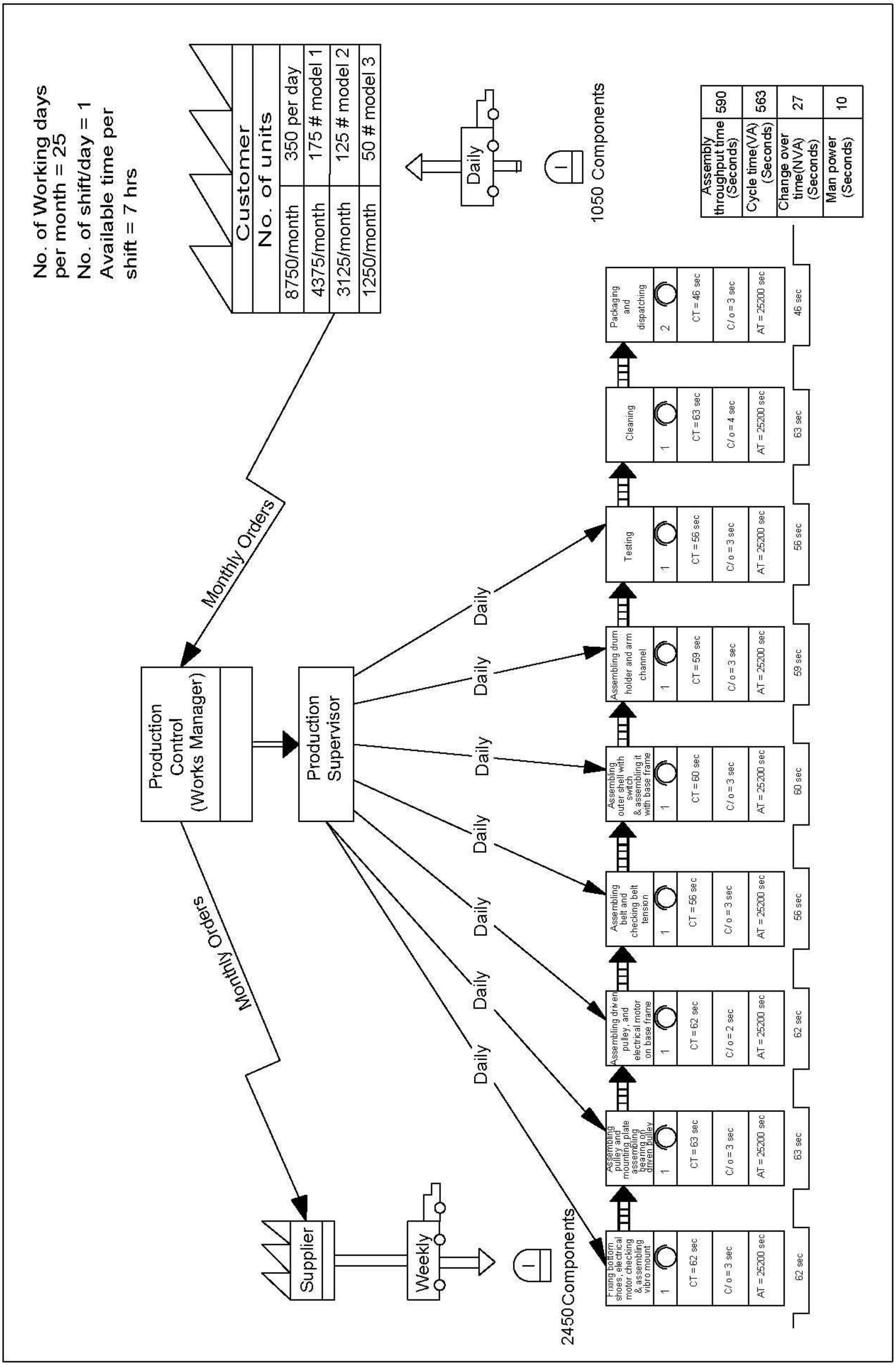
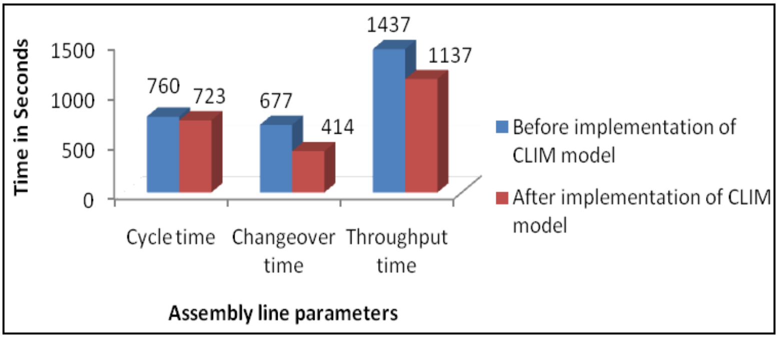
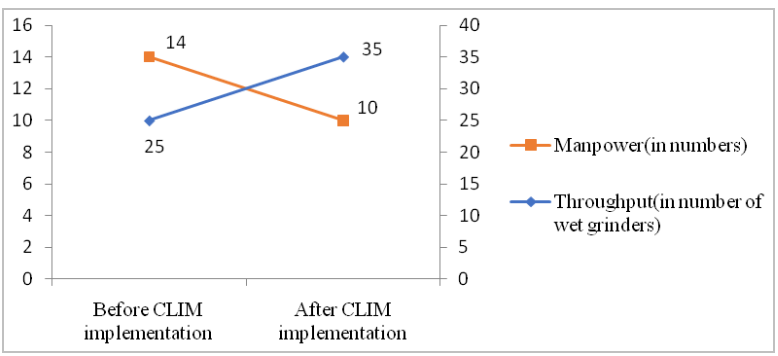


Figure 4 Comparison of assembly time parameters before and after implementing CLIM model (see online version for colours)



As shown in Figure 5, after implementing FSM, labour productivity has improved from 25 wet grinders per employee per shift to 35 wet grinders per employee per shift. Eventually the number of operator is reduced from 14 to 10 and the cost of employing four operators in the main assembly were reduced due to the implementation of the second phase of activities, encompassed in CLIM model. These four excess operators in the modified FSM are now employed in the new unit started by the same management.

Figure 5 Comparison of manpower before and after implementing the CLIM model (see online version for colours)



The cost to the company per operator varies between INR 12,000/month to INR 22,500/month. The average cost of manpower is INR 750 per day per operator, on implementing CLIM model, the employment of four operators could be reduced. The cost of manufacturing the wet grinders is thus reduced by INR 9,00,000 (that is, 4 operators × 25 days × 12 months × INR 750) in a year by employing only the adequate number of operators in XYZ. Thanks to the implementation of the first and second phases of CLIM model, the percentage of savings in labour achieved in XYZ is 28.8%. In total, the cost of assembling one unit of wet grinder is reduced by better utilisation of manpower.

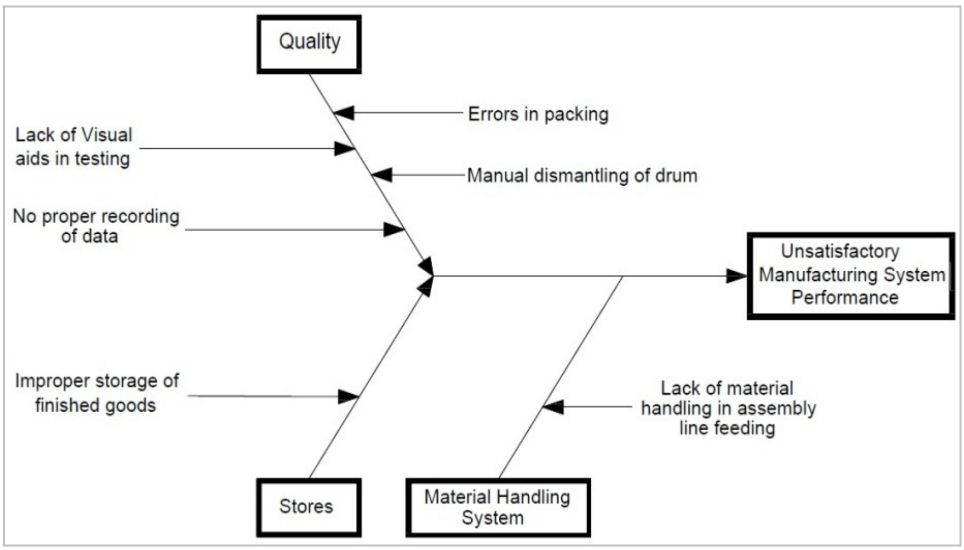
4.3 Phase 3: inculcating, monitoring and controlling

Practical training sessions about the lean strategies to be adopted in the main assembly and sub-assemblies, housekeeping using *5S*, maintenance and quality were conducted for the employees of XYZ. Subsequently, the results were evaluated against the SMART goal. The improvement in labour productivity to 35 wet grinders was achieved against the target. The outcome of the third phase inculcates the lean culture among the employees.

4.4 Phase 4: manufacturing system transformation

After reducing the manpower, the cause and effect diagram was constructed to indicate the causes of unsatisfactory performance of the manufacturing system. This cause and effect diagram is shown in Figure 6. As shown, the deficiencies that happen under the three support functions quality, MHS and stores are indicated.

Figure 6 Cause and effect diagram of improving the manufacturing support system



By referring to this cause and effect diagram, it was deduced that there was scope for achieving improvement in the MHS, quality and stores. Subsequently, these improvements were achieved in XYZ. These improvements and their implementation in XYZ are described in the following three sub-sections.

4.4.1 Improvements in material handling system

Re-designing the plant layout must go hand in hand with improvements in material handling and working conditions. Material handling involves motion, storage and quantity of materials throughout the process. The following points were focused while designing the MHS in XYZ.

- the required material (raw material, work in process, finished goods) must be supplied periodically from stores to the station
- the manufacturing process should not be interrupted
- the customer demand should not be lost due to the early or late arrival of materials

- the delivery of materials must be assured at the right quantity at the right place and at right time
- sufficient storage space should be allotted, both temporary and permanent.

The problems faced in the MHS and the improvements achieved are described below:

Problem and recommended solution 1: Currently the feeding of the drum to next station is manually carried out and hence, the supply is discontinuous as shown in Figure 7. Feeding conveyor has been introduced as shown in Figure 8. This conveyor ensures continuous feeding of the drum to the next station.

Figure 7 Improper feeding of the drum to the next station (see online version for colours)

Figure 8 Introducing drum feeding conveyor after the implementation of the fourth phase of the CLIM model

Outcome 1: Manpower requirement has been reduced from two to one. Reduction of the operator cycle time has been achieved. Introduction of conveyor also resulted in eliminating the confusion on identifying the processed and unprocessed drums.

Problem and recommended solution 2: Currently the feeding of the base frame to the next station is manually performed and the supply is discontinuous as shown in Figure 9. Feeding conveyor was introduced as shown in Figure 10. This conveyor ensures continuous feeding of the base frame to the next station.

Outcome 2: Reduced operator effort and cycle time. Introduction of conveyor improved product quality by avoiding manual movements.

Figure 9 Improper storing and feeding of the base frame (see online version for colours)

Figure 10 Systematic and continuous feeding of the base frame after implementation of the fourth phase of the CLIM model (see online version for colours)

4.4.2 Improvements in the quality department

The problems faced in the quality department and the implemented suggestions are described in the following sub-sections. During rework, drums were removed manually. This activity is shown in Figure 11. The time taken to carry out this activity is 30 seconds. In order to reduce this duration, pneumatic presses were introduced. The employment of the pneumatic presses is shown in Figure 12. The dismantling time is reduced from 30 seconds to ten seconds through the introduction of SMED concept.

Figure 11 Manual removal of the drum for carrying out rework (see online version for colours)

Figure 12 Introduced pneumatic press after the implementation of the fourth phase of the CLIM model (see online version for colours)

Figure 13 Manual acquisition of testing data (see online version for colours)

Figure 14 Introduced computerised data acquisition system after the implementation of the fourth phase of the CLIM model (see online version for colours)

4.4.3 Improvement in the recording of the test data

During the testing of wet grinder, the test data were recorded manually and the height of the operator affected the test parameters. This aspect is shown in Figure 13. In order to overcome this problem, online data acquisition was introduced for testing the wet grinders. This data acquisition system is shown in Figure 14. Thus, the height constraint of the operator was eliminated to facilitate data acquisition.

4.4.4 Improvements in stores department

There were incidents of missing components in assembled wet grinders as there was no standard work table. In order to overcome this deficient condition, a work table was placed. Further, *poka-yoke* was introduced in the packaging machine to prevent the missing accessories problem in the packaging. These facilities facilitated to enhance the operator efficiency. After implementing the CLIM model in XYZ for achieving the goals of implementing LP in the manufacturing support functions as discussed above, the procedure was well documented for achieving continual improvement in the form of reports in XYZ. The continual improvement of the assembly line and its support functions that met the SMART goals can be expanded to main assembly line 2 and for attaining other goals that may be set in future at XYZ. Implementation of the fourth phase of the CLIM model guided the XYZ to attain their ultimate goal of sustainability and profitable growth by better utilisation of manpower in the manufacturing process and its support functions as well as improving the MHS, quality and storage. Further, CLIM model has facilitated the standardisation of practices and made XYZ adopt LP practices for achieving performance improvement.

5 Conclusions

In this paper, the investigation on implementing LP through the CLIM model in a wet grinder manufacturing company has been reported. The outcome of this investigation indicated that the CLIM model is practically viable for implementation in the assembly line of wet grinder manufacturing company. The CLIM model ensures collectivism among workers, promoting integrated groups and less self-reliant individuals. Moreover, the CLIM gives a solution to problems in the floor shop to avoid uncertainty. Therefore, once a worker starts working as a team, he is encouraged to be more productive. XYZ was sensitised towards implementing LP after the implementation of the first phase of the CLIM model. It was also observed that through the implementation of the second to fourth phases of CLIM model, SMART goals were formulated and attained. The lean tools like VSM facilitated the identification of NVA and improvement of the current manufacturing process of the assembly line functioning in XYZ. Further, implementation of CLIM model facilitated to focus on the reconfiguration and restructuring of manufacturing functions thereby reducing the manufacturing cost. As a result of implementing the fourth phase of the CLIM model, the performance of the manufacturing support systems namely MHS, quality and stores were improved. Implementation of CLIM model in XYZ was successful and it gave rise to an indication that CLIM model facilitates to effectively implement LP in the assembly line of wet grinder manufacturing companies. CLIM model was implemented in XYZ in which assembly lines exist. In order to overcome this limitation, in future, researchers may strive to carry out investigations on implementing this model in other manufacturing companies in which multi-product manufacturing lines exist. These investigations will be useful to strengthen the practical validity of the CLIM model. The knowledge and experience gained by conducting these investigations may be used to refine the CLIM model. The CLIM model developed could be extended to service organisations and other industries. The impact of those implementations may be analysed to draw inferences which will be useful to the practising engineers and managers. This work can be extended to the whole enterprise by aligning and involving the stakeholders to attain lean goals.

References

Ahlstrom, P. (1998) 'Sequences in the implementation of lean production', *European Management Journal*, Vol. 16, No. 3, pp.327–334.

Anand, G. and Kodali, R. (2010) 'Analysis of lean manufacturing frameworks', *Journal of Advanced Manufacturing Systems*, Vol. 9, No. 1, pp.1–30.

Antony, J., Kumar, M. and Madu, C.N. (2005) 'Six Sigma in small- and medium-sized UK manufacturing enterprises', *International Journal of Quality & Reliability Management*, Vol. 22, No. 8, pp.860–874.

Anvari, A., Zulkifli, N., Yusuff, R.M., Hojjati, S.M.H. and Ismail, Y. (2011) 'A proposed dynamic model for a lean roadmap', *African Journal of Business Management*, Vol. 5, No. 16, p.6727.

Chowdhury, B., Deb, S.K. and Das, P.C. (2014) 'Managing and analyzing manufacturing defects: a case of refrigerator liner manufacturing', *International Journal of Current Engineering and Technology*, Vol. 2, No. 1, pp.54–61.

Devi, K.S., Arunachalam, V.P. and Gunasekaran, N. (2018) 'Lean manufacturing concepts in wet grinder assembly line through value state mapping', *International Journal of Services and Operations Management*, Vol. 30, No. 3, pp.357–370.

Duarte, S. and Machado, V.C. (2017) 'Green and lean implementation: an assessment in the automotive industry', *International Journal of Lean Six Sigma*, Vol. 8, No. 1, pp.65–88.

Gnanaraj, S.M., Devadasan, S.R., Murugesh, R. and Shalij, P.R. (2010) 'DOLADMAICS: a model for implementing Lean Six Sigma in contemporary SMEs', *International Journal of Services and Operations Management*, Vol. 7, No. 4, pp.440–464.

Goncalves, M.T. and Salonitis, K. (2017) 'Lean assessment tool for workstation design of assembly lines', *Procedia CIRP*, Vol. 60, No. 1, pp.386–391.

Holweg, M. (2007) 'The genealogy of lean production', *Journal of Operations Management*, Vol. 25, No. 2, pp.420–437.

Jadhav, J.R., Mantha, S.S. and Rane, S.B. (2014) 'Development of framework for sustainable lean implementation: an ISM approach', *Journal of Industrial Engineering International*, Vol. 10, No. 3, pp.72–82.

Jasti, N.V.K. and Kodali, R. (2016) 'An empirical study for implementation of lean principles in Indian manufacturing industry', *Benchmarking: An International Journal*, Vol. 23, No. 1, pp.183–207.

Karim, A. and Arif-Uz-Zaman, K. (2013) 'A methodology for effective implementation of lean strategies and its performance evaluation in manufacturing organizations', *Business Process Management Journal*, Vol. 19, No. 1, pp.169–196.

Kureshi, N., Qureshi, F. and Sajid, A. (2010) 'Current health of quality management practices in service sector SME', *The TQM Journal*, Vol. 22, No. 3, pp.317–329.

Malik, A. and Nilakant, V. (2011) 'Extending the 'size matters' debate: drivers of training in three business process outsourcing SMEs in India', *Management Research Review*, Vol. 34, No. 1, pp.111–132.

Maneechote, T. and Luangpaiboon, P. (2010) 'Production time reduction for erbium doped fibre amplifier process via lean manufacturing systems', in *Proceedings of the International Conference of Engineers and Computer Scientists*, Vol. 1285, No. 1, pp.372–386.

Mostafa, S., Dumrak, J. and Soltan, H. (2013) 'A framework for lean manufacturing implementation', *Production & Manufacturing Research: An Open Access Journal*, Vol. 1, No. 1, pp.44–64.

Motwani, J. (2003) 'A business process change framework for examining lean manufacturing: a case study', *Industrial Management & Data Systems*, Vol. 3, No. 5, pp.339–346.

Nadeem, S.P., Garza-Reyes, J.A., Leung, S.C., Cherrafi, A., Anosike, A.I. and Lim, M.K. (2017) 'Lean manufacturing and environmental performance–exploring the impact and relationship', in *IFIP International Conference on Advances in Production Management Systems*, Springer, Cham, September, pp.331–340.

Obeidat, M.S., Pei, Z.J. and Al-Aomar, R. (2014) 'Implementing lean manufacturing in the sewing industry', *Proceedings of the Institute of Industrial and Systems Engineers*, Vol. 4, No. 2, pp.151–171.

Panizzolo, R., Garengo, P., Sharma, M.K. and Gore, A. (2012) 'Lean manufacturing in developing countries: evidence from Indian SMEs', *Production Planning & Control*, Vol. 23, No. 10, pp.769–788.

Porter, M.E. and Lee, T.H. (2013) 'The strategy that will fix health care', *Harvard Business Review*, Vol. 91, No. 10, pp.1–19.

Romano, E., Santillo, L.C. and Zoppoli, P. (2009) 'Transformation of a production/assembly washing machine lines into a lean manufacturing system', *WSEAS Transactions on Systems and Control*, Vol. 4, No. 2, pp.65–76.

Rose, A., Deros, B. and Rahman, M. (2010) 'Development of framework for lean manufacturing implementation in SMEs', in *Proceedings of the 11th Asia Pacific Conference on Industrial Engineering and Management Systems*.

Serrano, I., Ochoa, C. and Castro, R.D. (2008) 'Evaluation of value stream mapping in manufacturing system redesign', *International Journal of Production Research*, Vol. 46, No. 16, pp.4409–4430.

Seth, D., Seth, N. and Dhariwal, P. (2017) 'Application of value stream mapping (VSM) for lean and cycle time reduction in complex production environments: a case study', *Production Planning & Control*, Vol. 28, No. 5, pp.398–419.

Shah, R., Chandrasekaran, A. and Linderman, K. (2008) 'In pursuit of implementation patterns: the context of Lean and Six Sigma', *International Journal of Production Research*, Vol. 46, No. 23, pp.6679–6699.

Smeds, R. (1994) 'Managing change towards lean enterprises', *International Journal of Operations & Production Management*, Vol. 14, No. 3, pp.66–82.

Sreedharan, V.R. and Sunder, M.V. (2018) 'A novel approach to lean six sigma project management: a conceptual framework and empirical application', *Production Planning & Control*, Vol. 29, No. 11, pp.895–907.

Sreedharan, V.R., Sandhya, G. and Raju, R. (2018) 'Development of a green Lean Six Sigma model for public sectors', *International Journal of Lean Six Sigma*, Vol. 9 No. 2, pp.238–255.

Temtime, Z.T., Chinyoka, S.V. and Shunda, J.P.W. (2003) 'Toward strategic use of IT in SMEs: a developing country perspective', *Information Management & Computer Security*, Vol. 11, No. 5, pp.230–237.

Thomas, A., Barton, R. and Chuke-Okafor, C. (2009) 'Applying lean six sigma in a small engineering company – a model for change', *Journal of Manufacturing Technology Management*, Vol. 20, No. 1, pp.113–129.

Womack, J. and Jones, D. (2003) *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*, 2nd ed., Simon & Schuster Ltd., UK.

Yusuf, S.M. and Aspinwall, E. (2000) 'Total quality management implementation frameworks: comparison and review', *Total Quality Management*, Vol. 11, No. 3, pp.281–294.