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Research paper



Real time implementation and validation of lean implementation model for sustainability (LIMS) in medium scale industry

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Abstract

Lean manufacturing is a strategic tool, which is used to cut down waste and to improve the efficiency of an organization and helps the organization to sustain in the competitive environment. Implementation of lean systems in organization results in reduce energy consumption, waste generation, and hazardous materials used while also building the companies' images as socially responsible organizations. Several research efforts discussed in the literature indicate that lean companies show significant environmental improvements by being more resource and energy efficient. Lean systems are associated with waste reduction techniques. In foreign, many industries have started implementing these concepts and they are getting good results. In India, companies are facing problems in implementing lean concept. Critical success factors for lean system implementation in Indian medium scale manufacturing industries has been identified to overcome it. The factors are grouped into different levels by Interpretive Structural Modelling (ISM). A lean implementation model has been developed for medium scale industry and named as 'LIMS'. This paper investigates the implementation and validation of the LIMS through the real time implementation in a medium scale industry.

Keywords: *Lean Manufacturing; ISM; LIMS; Critical Success Factor (CSF).*

1. Introduction

Lean manufacturing or lean production, often simply "lean", is a systematic method for the elimination of waste or muda within a manufacturing system (Upadhye et al., 2010; Ping-yu, Yang, 2009). Lean also takes into account waste created through over burden or muri and waste created through unevenness in workloads or mura (Shah, Rachna, and Peter T. Ward, 2007). The seven types of wastes are defined as Overproduction, Waiting, Transportation, Inventory, Over Processing, Motion and Defects. Constant effort at cost reduction is required to maintain continuous profits in manufacturing. The prime way to reduce costs is to produce only those products determined by sales in a timely fashion, to restrain excessive manufacturing and to eliminate all waste in manufacturing methods (Achanga, P., et al., 2005
Diaz-Elsayed, Nancy, et al., 2013). There are various ways to analyze and implement cost reduction, from the start of designing all the way through to manufacturing and sales (Cezar Lucato and Wagner, 2014; Fullerton, Rosemary R et al., 2003). One of the goals of lean manufacturing is to locate waste in each process and then eliminate it. It is possible to uncover a very large amount of waste by observing employees, equipment, materials and organization on the actual production line from the perspectives of the process itself and the actual work involved (Bhasin, Sanjay, and Peter Burcher, 2006). Some types of waste are obvious, but others are hidden. Waste never improves value; it only increases cost. The thorough elimination of waste leads to greater employee self-respect and to major cost reductions by preventing unneeded losses (Browning, Tyson R., and Ralph D. Heath, 2009).

2. Lean tools

Lean tools that are assist in the identification and steady elimination of waste. As waste is eliminated, quality improves while production time and cost are reduced (Ramesh V. Narang). A non-exhaustive list of such tools are Just In-Time (JIT), Five S (5S) (Rojasra, P. M., and M. N. Qureshi, 2013), Bottleneck analysis, Continuous flow, Value Stream Mapping (VSM), Single Minute Exchange of Dies (SMED), Kanban or Small batch sizes, Kaizen, Poke-a-Yoke or Error-proofing and Total Productive Maintenance (TPM) (Samson Danny and Mile Terziovski, 1999; Cua at al., 2001).

2.1. Benefits of lean manufacturing

The benefits of lean manufacturing are evident in many industries throughout the world. Industries report improved product quality, reductions in cycle time, reduced work in progress (WIP), improved on-time deliveries, improved net income (McKone et al., 2001), decreased costs, improved utilization of labor, reduction in inventories, quicker return on inventory investment, higher levels of production, increased flexibility, improved space utilization, reduction in tool investment, a better utilization of machinery, stronger job focus and better skills enhancement. Typical results reported (Zimmer 2000; Pavnaskar, Gershenson et al. 2003) after successful lean implementation indicates:

- 50% or greater increases in capacity in current facilities
- 80% reduction in floor space
- 50% improvement in quality

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- 95% machine availability
- 80–90% reduction in changeovers
- 60% reduction in cycle times

Typical characteristics of a lean industry include integrated single piece flow; defect prevention; production pill; continuous waste reduction; flexible team based work; active involvement and close integration with suppliers (Womack and Jones 2003). Some of the very common benefits include

- Decreased lead times for production.
- Reduced inventories.
- More robust process.
- Improved knowledge management.

From Toyota Production System (TPS) to lean industry and lean supply chain practitioners can easily find plenty of tools to improve projects. However, applying all lean tools at once only leads to chaos. Selecting the right tools for their current condition becomes the key to success in lean implementation. This paper deals about the development of generic lean model for lean implementation and enlighten the real time validation of the lean model in a medium scale industry to improve the productivity.

3. Development of lean implementation model for sustainability in medium scale industries

The representation of real world in terms of either graph or mathematical equations or structure is known as modeling. The modeling is classified into three types based on their degree of concept related with the real one. They are,

- Iconic model like model airplane or train
- Analogous model such as chart, graph, map and network diagram
- Symbolic model such as mathematical equation
- This paper deals about the analogous modeling of lean manufacturing process.

3.1. Lean modeling

Lean modeling is a strategy used in the industry to eradicate the waste systematically during the process to fulfill the customer needs. The customer satisfaction will make the industry to get more returns and brand name (Marasini et al., 2014). The goal of the lean model is to maintain the customer for longer run (Bergmiller, Gary G., and Paul R. McCright, 2009). In all lean implementation involves basically three practices such as just-in-time inventory, total quality management and continuous improvement to reduce the waste and improve the quality with compact price.

3.2. Development of generic lean model for medium scale industries

It is a difficult assignment to implement the new concept in medium scale industries in India because of unskilled employee who hesitate to switch over to a new methodology and environment (Chikhalikar, Pratik and Suman Sharma, 2015; Nellore, Rajesh ET al.1999). This work proposes an easy to implement and low cost model for medium scale industries and it is named as Lean Implementation Model for Sustainability (LIMS) and is shown in Figure 1.

As a first step, the entire process is subdivided into six major sections to develop a lean model as follows,

- Identification of critical success factors (CSF)
- Ranking and prioritization of CSF based on weightage determined by using ISM technique
- Analysis of current status for lean implementation
- List and summarize the feasible CSF for lean implementation
- Initialize the lean implementation for each CSF
- Pilot analysis, monitoring and control

3.3. Identification of critical success factors (CSF)

The critical success factors which are the barriers for lean implementation in medium scale industries to be identified based on the field survey and experts' opinion. Then prioritize the identified critical success factors by using any one the MCDM techniques.

3.4. List and summarize the feasible csf for lean implementation

The status need to be assessed before implementation of lean. It can be done through getting feedback from management regarding financial constraints, employee regarding adaption to new environment, customer regarding the satisfaction level and supplier about the quality raw material
(Flynn et al., 2004). Based on the feedback received, it is possible to ascertain the current situation of the industry and able to list the problems in it. The problems can be identified through the feedback from the management, employee, customer and supplier. Then the analysis needs to be done to find out the causes for each problem. There are several tools available for analysis the causes of the problems like,

- Cause and effect diagram
- Flow diagram
- Histogram
- Pareto chart
- Scatter diagram
- Control charts and
- Trend chart

Once the problems are identified, prioritization of the problems needs to be done immediately for improvement.

3.5. Pilot analysis monitoring and control

Now it is the time to implement the lean concepts instead of traditional practices. It is well known that there are a lot of challenges and barriers during implementation and it should be addressed properly. First and foremost step is to train the employees for a day or a week according to the feasibility of the industry in each level through lean consultants for a better implementation. The lean implementation process will not end merely at execution level and it needs continuous monitoring and corrective actions at each level to reach the target level. It can be executed by statistical quality control (Flynn et al, 1994; Narasimhan et al., 2006).

4. Real time implementation of LIMS model

The proposed LIMS model has been implemented in MSI-X, Hosur to validate it. MSI-X is manufacturing locomotive products like gear box, gear wheel, piston rod and connecting rod with the support of 40 employees. The Table 1 shows the consolidation of six month report of production database.

Table 1: Consolidated Report of MSI-X before Lean Implementation

Description	Jun-2014	Jul-2014	Aug-2014	Sep-2014	Oct-2014	Nov-2014	Six Month Avg.
Avg. units of production/ day	822	796	790	824	812	820	810.67
Avg. units accepted in first level/ day	720	714	722	723	752	740	728.50
% of accepted units in first level/ day	87.59	89.70	91.39	87.74	92.61	90.24	89.86
Average units rejected/ day	102	82	68	101	60	80	82.17
Average units of rework/ day	12	8	5	14	6	9	9
Average units of scrap/day	90	74	63	87	54	71	73.17

Average of finished units/day	732	722	727	737	758	749	737.50
% of finished units in final stage/day	89.05	90.70	92.03	89.44	93.35	91.34	90.97

From the Table 1 it is observed that the average productivity per day is 810 units of gear box, gear wheel, connecting rod and piston rod. Among the total production 728 units are accepted and 82 units are rejected in the first level. In the rejected quantity 9 units have undergone for rework and the average finished products at the final become 737 units and the level of productivity is 90.97%. The month wise report of average units of production, finished products and scrap per day before lean implementation is depicted in Figure 2. The average cost for raw material per month is rupees four crores.

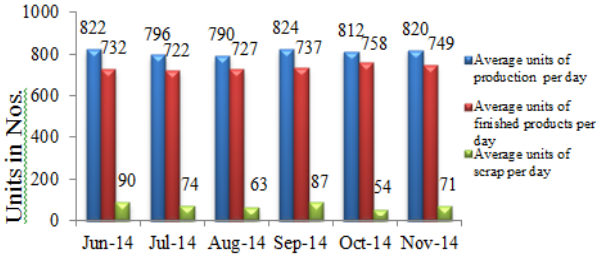


Fig. 2: Monthly Reports on Production, Finished Products and Scrap before Lean Implementation.

4.1. Lean implementation for each CSF

From the above discussion, it is clear that the average productive rate per day of the industry is 90.97 %. It is considerably low and it should be addressed properly through lean implementation. The lean tools chosen and method of implementation is discussed in the succeeding sections.

The lean implantation process started in MSI-X from the month of December 2014. To implement the above said lean concepts and get practiced by the employees, it has taken four months from December 2014 to March 2015. The monitoring and control has taken place at every step and remedial actions are taken then and there suitably. The improvement of the industry has measured from the month of April 2015 in terms of its productivity as shown in Table 2.

Table 2: Consolidated Report of MSI-X after Lean Implementation

Description	Apr-2015	May-2015	Jun-2015	Jul-2015	Aug-2015	Sep-2015	Six Month Avge
Avg. units of production/day	831	802	820	815	821	818	817.83
Avg. units accepted in first level /day	742	738	765	794	798	795	772.00
% of accepted units in first level/day	89.29	92.02	93.29	97.42	97.20	97.19	94.40
Avg. units rejected/day	89	23	55	21	23	23	39.00
Avg. units of rework/day	10	4	12	0	3	2	5.17
Avg. units of scrap/day	79	19	43	21	20	21	33.83
Avg. of finished units/day	752	742	777	794	801	797	777.17
% of finished units in final stage/day	90.49	92.52	94.76	97.42	97.56	97.43	95.03

From the Table 2 it is observed that the average productivity per day is 817 units of gear box, gear wheel, connecting rod and piston rod. Among the total production 772 units are accepted and 39 units are rejected in the first level. In the rejected quantity [5] units have undergone for rework and the average finished products at the final become 777 units and the level of productivity is 95.97 %. The month wise report of average units of production, finished products and scrap per day after lean implementation is depicted in Figure 3.

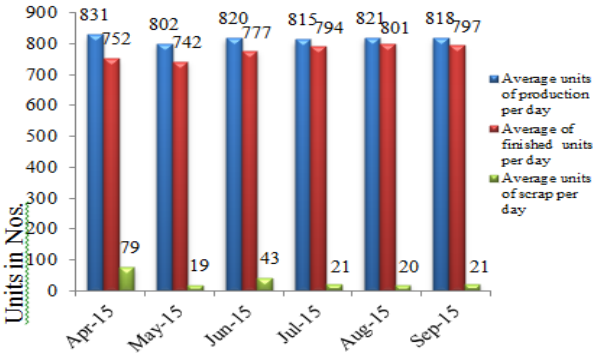


Fig. 3: Monthly Reports on Production, Finished Products and Scrap after Lean Implementation.

It is found happy that the production status of MSI-X has shown a better improved after lean implementation. It is evident from the Table 3 and Figure 4 that the average production unit per day has improved from 810.67 units to 817.83 units due to lean implementation. Similarly there is a remarkable improvement in the level of units accepted per day as 94.40 % from 89.86 %. There is a reduction in units considered for rework is reduced to five units per day. At the same time, the scrap is also dropped to 33.83 units per day which is a significant improvement than the previous situation. Due to the above said factors, the productivity of the industry has been improved considerably by five percentages after the lean implementation as shown in Table 3 and Figure 5.

Table 3: Production Status of MSI-X before and after Lean Implementation

Description	Six Month Average	
	Before Implementation	After Implementation
Average units of production per day	810.67	817.83
Average units accepted in first level per day	728.50	772.00
% of accepted units in first level per day	89.86	94.40
Average units rejected per day	82.17	39.00
Average units of rework per day	9	5.17
Average units of scrap per day	73.17	33.83
Average of finished units per day	737.50	777.17
% of finished units in final stage per day	90.97	95.03

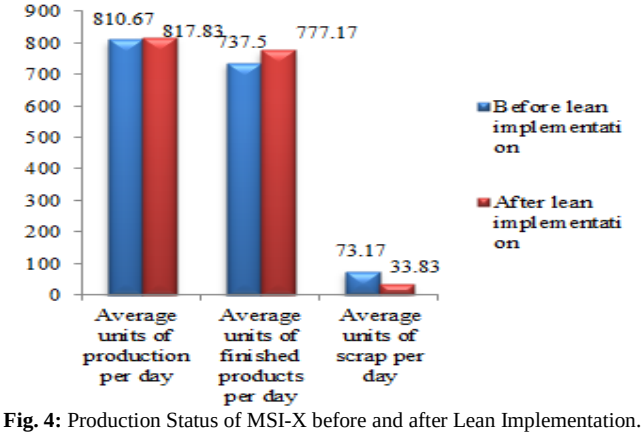


Fig. 4: Production Status of MSI-X before and after Lean Implementation.

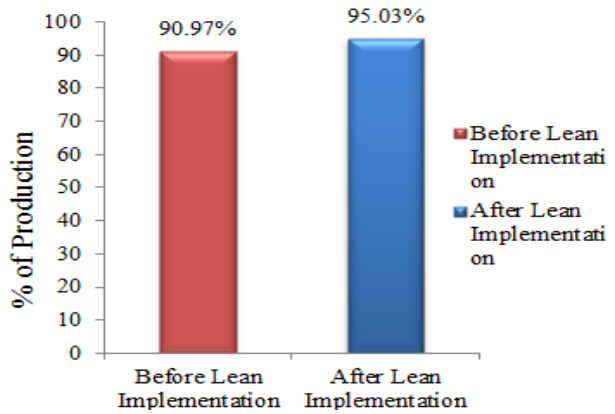


Fig. 5: Productivity Rate before and after Lean Implementation.

5. Conclusion

The development and real time implementation of lean manufacturing model in medium scale industry has been proposed in this paper. The generic lean modeling named LIMS has been proposed for implementing the lean concept in the medium scale industries. The developed model has divided into six major sections. The lean tools like Five S, JIT, Kaizen, six sigma and poke-a-yoke have been suggested for economical and easy implementation in the medium scale industries. As suggested in LIMS model, the current status of the industry has been analyzed and the level of productivity has 90.97 %. Based on the analysis, it has been identified that strong management and leadership, education and training, employee trust, flexible workforce and supplier relationship and involvement as the major critical success factors for the industry. The preferred lean tools such as Five 'S', Kaizen, SMED and JIT have been implemented to improve the productivity.

During the implementation the proper training has been organized for the people working in different level to improve the leadership skill for managers and the supervisors, to imbibe the lean concept and skill oriented training among the workers. To enhance the employee trust the reward system has been implemented through Kaizen and it has helped small improvements. The relationship among the industry and the supplier has strengthened through JIT concept. The flexible work force situation has been implemented by developing cross functional skills. After the lean implementation, the analysis has been made to measure the productivity rate and it became as 95.97 %. The observed results are found to be encouraging and provide appreciable improvements in the productivity rate.

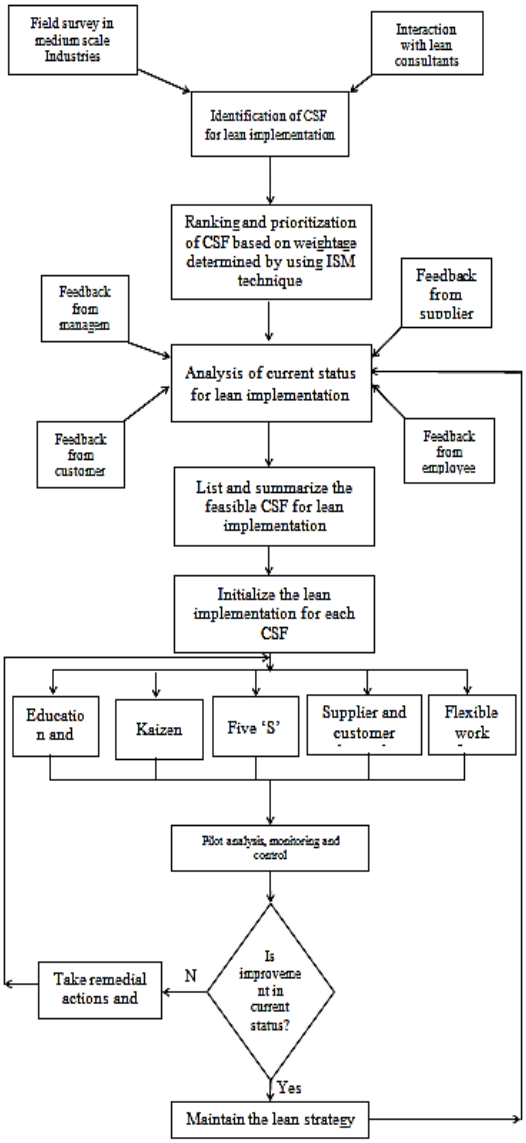


Fig. 1: Lean Implementation Model for Sustainability (LIMS).

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