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Lean manufacturing techniques – Implementation in Indian MSMEs and benefits realized thereof

Indrajit Bhattacharya[a*] & Anandhi Ramachandran[b]

[a]Quality Council of India (QCI), National Accreditation Board for Education and Training (NABET), New Delhi 110 002, India

[b]International Institute of Health Management Research, Delhi 110 065, India

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The purpose of this paper is to highlight the importance of implementing Lean manufacturing techniques for enhancing market competitiveness and productivity in the Indian MSMEs. The methodology adopted is a multi-case study approach based on the primary implementation of Lean manufacturing techniques in the MSMEs under the Lean manufacturing competitive Scheme (LMCS) Scheme of the Ministry of Micro, Small, Medium and Medium Enterprises (MSME),Govt. of India since 2014. Out of the 243 clusters formed under LMCS; 43 clusters have completed the 18 months lean journey for enhancing the productivity and competitiveness till the study period. A sample size of 6 clusters each representing a specific sector has been selected for the study. The sectors covered were brass, pump and machinery, packaging, auto, textile and garments. The validation study carried out by the national monitoring committee on randomly selected 23 MSME units has also been explored for understanding the quality of benefits achieved by the MSMEs post implementation of Lean. The study period has been since July 2014 to July 2018. Investment in the form of fees paid to Lean consultants has led to 8.32 times returns on consultant fee over an 18 months period. Moreover, the completed cluster has realized an average of ₹28.35 lacs per unit after completing lean interventions in the units. There has been a reduction in cost, reduction in waste, improvement in quality and increase in lead time. Additionally, a number of non-tangible benefits have been realized such as improved worker performance, worker health and safety besides increased customer satisfaction etc. by the MSME units across the sectors. This study establishes that up-scaling of 'Lean manufacturing technique practices' is required en-masse across the entire MSME sector quickly so that they can realize the benefits of Lean and invest in sustainable Industry 4.0 techniques leading to Advanced Digital Production (ADP) techniques. The data driven smart manufacturing would enable the MSMEs to maintain competitiveness in the global markets through innovation and internationalization, resource optimization and flexible manufacturing.

Keywords: Lean manufacturing competitive scheme (LMCS), Micro small and medium enterprises (MSME), Lean manufacturing consultant (LMC), Lean tools and techniques (LTT), 5S, Kaizen, Value stream mapping (VSM)

1 Introduction

The Micro, Small and Medium Enterprises (MSMEs) are the largest contributors in terms of employment generation in the manufacturing sector. They are a significant part of the value chain in almost all leading industry sectors such as automobiles, garments and textile industry, leather industry etc. Recognizing the importance of overall economic growth of a country and the need for enhancing its productivity, competitiveness and employment generation and quality of manufacturing, many countries have institutionalized Lean production mechanisms in their national approach on manufacturing.

*Corresponding author (E-mail: indrajitbhat@gmail.com)

1.1 The goals of lean

a. Improve quality: In order to stay competitive in today's marketplace, a company must understand its customers' quality benchmarks and design needs to meet their expectations and requirements.
b. Eliminate waste: Waste is any activity that consumes time, resources, or space but does not add any value to the product or service.
c. Reduce time: Reducing the time it takes to finish an activity from start to finish is one of the most effective ways to eliminate waste and lower costs.
d. Reduce total cost: To minimize cost, and improve profit margins, a company must produce only to customer demand. Overproduction increases a company's inventory costs due to storage needs.

Implementation of lean tools and techniques helps the industry in improving their competitiveness by way of i) Reducing waste and ii) Increasing Productivity like reducing cycle time of products; reducing cost of product (labour cost, material cost, overhead cost); energy conservation; productive space utilization & Machine utilization; and green productivity (pollution control & prevention)[1]. The principles of lean are:

1.2 Principle of lean

a. Define value from customer perspective: Specify value from the standpoint of the end customer by product family.
b. Identify the value stream: Identify all the steps in the value stream for each product family, eliminating whenever possible those steps that do not create value.
c. Make the process flow smooth: Make the value-creating steps occur in tight sequence so the product will flow smoothly towards the customer
d. Pull from the customer: Manufacture as per customer demand only

As value is specified, value streams are identified, wasted steps are removed, flow and pull are introduced, the process is repeated again and continued until a state of perfection is reached in which perfect value is created with no waste.

Lean manufacturing (Fig. 1) is a manufacturing philosophy that shortens the time line between the customer order and the product shipment by eliminating waste[2,3].

The waste may occur due to defects requiring rework, overproduction, waiting for materials or information, transportation, inventory etc[5].

The lean management methods and tools are divided into four basic categories, namely, stable and reliable systems, in process quality assurance, continuous improvement and just in time production[6,7]. Adoption of lean management tools are known to improve quality, increase productivity, reduce setup time, improve customer satisfaction, reduce costs and wastages, increase Overall Equipment Efficiencies(OEE) , reduce lead time and enhance profitability[3,8]. The lean principles cannot be implemented exactly the same way in every industry and therefore the firms need to select proper tools and techniques based on sector of industry, work culture advancements, status of shop floor, infrastructure availability and working conditions of specific industry. The implementation of lean philosophy demands a motivated and trained work-force and committed top management which is not available in most MSMEs as of now.

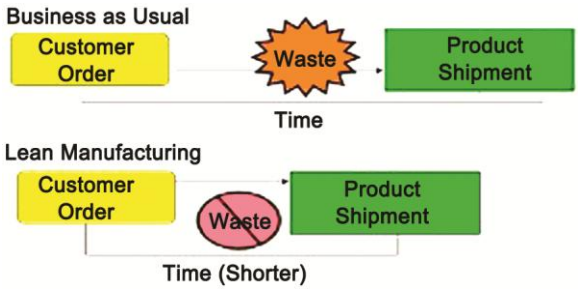

Fig. 1 — Lean manufacturing philosophy[4].

There are many reports in literature to show that Lean Manufacturing has been successfully implemented in large and medium size enterprises. Small and Micro Enterprises although looking for competitive advantage are generally apprehensive to change. To gain competitive advantage in the global market many organizations are proactively looking towards avenues to improve their business operations. Introducing lean methods would be a good starting point. It has been stated by many authors that there are many barriers and challenges in implementing lean manufacturing principles[9-12]. While extensive literature on implementing Lean manufacturing[13] is available, very few is available related to micro, small and medium enterprises (MSMEs)[13-15]. It has been stated that for a successful implementation in SMEs proper planning needs to be carried out[16]. Most of the SMEs believe that implementing lean manufacturing is costly and time consuming[13]. They generally have fewer resources and often less access to capital[17]. Also, SMEs are generally family run businesses or owned by single person. They do not trust external persons to guide them to run their business. Also, they do not make strategic plans in terms of a longer period or expansion of their business in large volume. However, they have shorter communication channels between themselves and their suppliers, customers and employees. If they can be convinced to adopt lean manufacturing principles, implementation would be easy.

India's manufacturing sector is projected to reach US$ 1 trillion by 2025[18]. It is believed that the sector will account for 25-30 percent of the country's GDP and create up to 90 million domestic jobs by 2025[18]. MSMEs are a vital part of the Indian economy contributing to over 45% of Industrial production and around 40% of the total exports[19]. Ever changing

globalized environment has been posing challenges of competitiveness and survival to all the constituents of the economy. It has been more so for MSMEs in the manufacturing sector. MSME play an important role in the 'Make in India' initiative of the Government of India[20].

In order to enhance the manufacturing competitiveness of MSMEs, Lean Manufacturing Competitiveness Scheme (LMCS) that involves application of various Lean Manufacturing (LM) techniques was implemented in 2013 for the benefit of the MSMEs[21,22]. The objective of the scheme is to enhance the manufacturing competitiveness of MSMEs through application of various Lean manufacturing techniques that will help in reducing waste, increase productivity, introduce innovative practices for improving overall competitiveness, inculcate good management systems and imbibe a culture of continuous improvement and quality. Under the LMCS (Fig. 2), clusters are formed comprising 6-10 MSME units, and various lean tools and techniques (LTT) are implemented for a period of 18 months with the help of a lean management consultant (LMC). So far, a total of 243 clusters have been formed. The fees for the LMC is subsidized by the government (80% of consultant fees) while the remaining 20% needs to be borne by Industry.

The National Accreditation Board for Education and Training (NABET) under Quality Council of India (QCI) as National Monitoring and Implementation Unit (NMIU) helps to implement and monitor the process. LMCS is implemented as a three-tier model[23] (Fig. 3). At the lowest tier mini clusters are formed and each assigned a LMC to implement the specific lean manufacturing techniques. At the next higher-level tier, National Monitoring and Implementing Units (NMIUs) are responsible for facilitating, implementation and monitoring of the scheme. At the highest level, a screening and steering committee provides overall direction of the scheme and is headed by the Development Commissioner (DC) of MSME.

The work of LMC is divided into 5 stages as indicated in Table 1.

Stage 1: Diagnostic Study Report (DSR)

This is the first stage wherein Consultant collects the baseline data with respect to –

- Existing status (5s, workspace management, safety, health, energy conservation, Single Minute Exchange of Dies (SMED)[2], Total Productive Maintenance (TPM), reduction in inventory, organization structure, layout, process of manufacture, visual baseline survey, identification of 7 wastes, inventory practices, top chronic problems, etc.)
- Time bound targets for achieving incremental improvements.

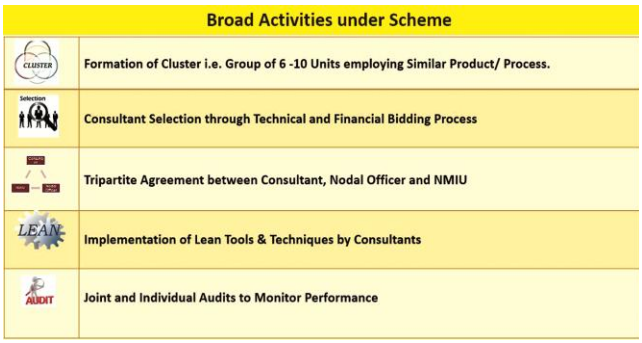

Fig. 2 — Broad activities under lean manufacturing scheme.

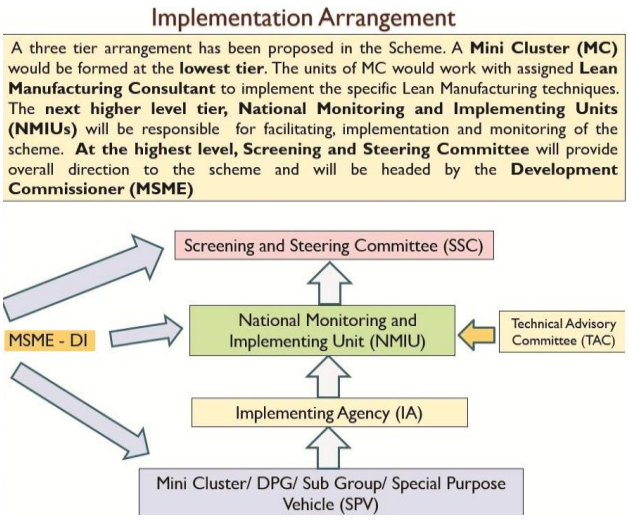

Fig. 3 — Implementation arrangement of lean manufacturing competitive scheme (LMCS) of MSME[21].

Table 1 — Stages of implementation.

Stages	Consultant Intervention	Intervention of Assessment
I – DSR	Diagnostic Study Report (DSR) and Action Plan	NMIU(Assessor) and Development Institute – DI (State)
II – MBR 2	Milestone Based Report -2	NMIU(Assessor)
III- MBR 3	Milestone Based Report -3	NMIU(Assessor) and Development Institute – DI (State)
IV - MBR 3	Milestone Based Report -4	NMIU(Assessor)
V - MBR 3	Milestone Based Report -5	NMIU(Assessor) and Development Institute – DI (State)

- Phase wise action plan
- Qualitative, quantitative, monetary benefits likely to be achieved

Stage 2: Milestone Base Report 2 (MBR-2);

Stage 3: Milestone Base Report 3 (MBR-3);

Stage 4: Milestone Base Report 4 (MBR-4);

Stage 5: Milestone Base Report 5 (MBR-5)

- 2nd, 3rd, 4th & 5th Milestones: - Incremental Improvements to next stage as per the plan mentioned in diagnostic study report (DSR)
- The units in conjunction with LMC works on the projects being identified at DSR Stage for improving their competitiveness and keep record of the gains occurred during the implementation phase.
- LMC in close coordination with the Mini Clusters will document/ prepare before and after status of various parameters.
- The documentation could be in form of case study, photographs, videos, etc.
- Each stage of implementation is being audited by QCI, while audit of 1st, 3rd and 5this carried out jointly along with MSME - Development Institute.

An As-Is study had been carried out for each cluster by the LMC. There are eleven lean tools specified under LMC. Based on the status of the manufacturing unit, sector and suitability of the application of tool, the consultant decides to apply a minimum set of 8 Lean tools from Table 2.

LMCS Guidelines[21] defines the following performance parameters and targets- 5S, workplace management, safety, health, energy conservation, single minute exchange of dies, total productive maintenance, reduction in inventory, organization structure, layout, process of manufacture, visual baseline survey, identification of 7 wastes, inventory best practices, and identification of key chronic problems .

For monitoring of above data baseline data are being captured from units depending on the applicability – labour productivity; capital productivity; annual savings (In ₹ lacs); quality (rejection ppm); inventory turnaround ratio (ITR); number of kaizens; recognition certificates; HR development- training man hours; lead time; value add ratio; on time delivery; throughput yield; equipment availability; overall equipment effectiveness (OEE); floor area freed up; quality performance; and TAKT (average time between the

Table 2 — Lean tools specified under LMCS 2013[21].

Lean tool	Description
5S	Workplace management which helps in getting the 'junk' out of the work area and set of procedures to keep it that way. 5S stands for sort, set in order, shine, standardize & sustain.
Visual control	Visual controls such as cartoons, charts, light signals, Lane marking on floor, safety instructions, warning signs, Poka-Yoke instructions etc., can be displayed all over the work place.
Standard operating procedure (SOP)	All verbal instructions should be converted to SOPs to remove dependency on skilled personnel in achieving required product quality level, consistency, effectiveness and efficiency.
Just in time (JIT)	Japanese manufacturing philosophy to make the right product in right quantity at the right time. This almost results in zero inventory and shortest possible cycle time
Kanban systems	In this, components are pulled by assembly or subsequent work centers and the containers are replenished with the right quantities by the previous work center, which reduces the inventory of unwanted components.
Cellular layout	In this improved manufacturing system, family wise component completion is aimed at within the smaller self contained cell, which is a part of a big factory, as compared to operation wise completion in traditional functional layout.
Value stream mapping (VSM)	Covers all activities, both value added and non-value added, and helps in arriving at best layout of all resources required for making the product.
Poke yoke or Mistake proofing	Japanese technique used to prevent errors occurring at their source of origin and it finally leads to a 'ZeroDefects' situation.
Single minute exchange of dyes (SMED)	Applying ingenious methods, set up time is minimized and brought to less than ten minutes; thereby smaller batches as required by the customer can be taken up for manufacturing.
Total productive maintenance(TPM)	TPM involves operators, maintenance staff and management working together to improve overall operation of any equipment. Operators, who first identify noisy or vibrating motors, oil or air leaks, can be trained to make simple repairs to prevent major and costly breakdowns.
Kaizen blitz or rapid improvement process	Intense management programme, which results in immediate change and bottom line improvement. Both management staff and workers are involved in this.

start of production of one unit and the start of production of the next unit) time.

2 Purpose of the study

Lean manufacturing in India in MSMEs is still in its infancy stage and the awareness level of Indian firms on lean manufacturing is very low. The concept is largely adopted only by large industries and small and medium sized firms in India are still mostly unaware of lean principles. There is a strong need for a better understanding of the qualitative and human factors that affect the success of lean implementation. Successful implementation of lean management is influenced by complex interplay of regional, organizational, technical, economic, social and cultural factors. The purpose of the current paper is to disseminate the outcomes of lean management implementation in MSMEs under LMCS scheme and to identify the barriers, challenges and the benefits achieved in implementing Lean management in Indian MSMEs. The study does not attempt to analyze the appropriateness and benefit realized by adoption of a particular Lean tool as each unit had freedom under LMCS to adopt any 8 set of tools from those listed under the scheme.

Additionally, there are very few literature studies related to lean management in MSMEs in India[24,25] and this study is expected to bridge the gap.

3 Methodology

The study adopted a case study approach as this approach has been successfully used in the past to disseminate the outcomes and identify factors for successful implementation of lean management[26-28]. Out of the 243 clusters formed under LMCS in the country, 43 have already completed the lean implementation cycle, during the study period. The 43 clusters belong to 6 groups each representing different sectors related to brass, auto packaging, pump and machinery, textiles and garment industries.

The lean implementations of all the units in the six clusters were followed as longitudinal case studies. In each cluster the issues and concerns particular to the cluster were first identified by the consultant by interacting with various management personnel, supervisors and workmen. These issues and the tools used by the consultant to train the various stakeholders, the implementation process, the barriers identified during implementation, the benefits realized after implementation were documented. A four-member committee was formed by NMIU to validate the lean management implementation process by the consultants and understand the ground reality. The clusters were reviewed based on nine assessment parameters and key personnel's views to assess the lean management implementation process.

While all the units in each of the six clusters have been studied, one unit from each cluster has been depicted in this paper as an example model unit. These types of multiple case studies are lacking in research related to lean management in MSMEs. Additionally, the observation made by the NMIU team is also highlighted in the paper.

The research limitations are that the study has been based on a sample size of 43 clusters comprising about 347 MSME units that may not be representative of the entire gamut of MSMEs sectors and geographical spread prevalent in the manufacturing sector in India.

4 Results

The following section briefly highlights the challenges faced, the tools utilized and the benefits realized by the model units on Lean implementation.

4.1 Case study 1: Brass component cluster

The cluster is located at Jamnagar, Gujarat and has total 9 units. Some of the products manufactured in this cluster were distribution boxes, electrical transmission, rail mounting terminals, energy meters, hrc & fuse fittings, plastic molding inserts, shower hinges, builder hardware handles, stainless steel handle, door locks, euro profile cylinders, door closers, floor springs and patch fittings, glass connectors, tyre tube valve accessories, automotive tube valves, tubeless tyre valves, brass auto parts etc. The model unit studied in this cluster was Jay Industries.

Some of the challenges identified in the company were uneducated workforce, high wastage in inventory, no improvement culture, workers not interested in improvement, untrained workers, and unorganized work area, poor maintenance of machines, poor plant layout and uncontrolled cycle time. To address these issues the following tools were deployed: 5S (Housekeeping), Kaizen, Visual Management, SOPs for all critical processes, KAIZEN collection, selection and monitoring system established, improved inventory management, changed plant layout and training of workmen on lean management way of working. The following Fig. 4 illustrates the benefits realized in the cluster after implementation of lean management principles.

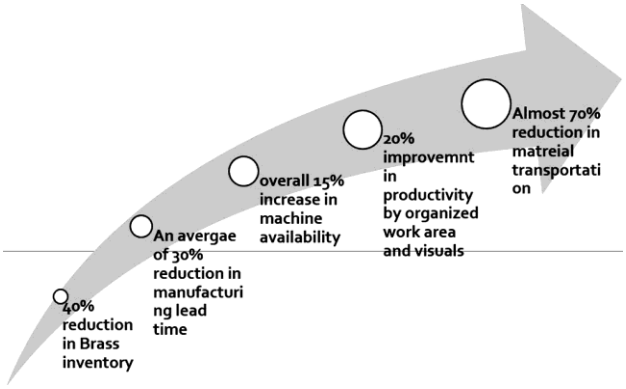

Fig. 4 — Benefits realized in brass cluster.

4.2 Case study 2 : Pump and machinery cluster

Pump and Machinery Lean Cluster consists of 7 units and is situated at Palanpur in Banaskatha District. Palanpur is around 145 Km from the state capital and mostly dry area of Gujarat. Water is always precious for this region of Gujarat. The model unit studied was Duke Pumps. It is one of the biggest Pump Suppliers across India. DUKE Pumps has also developed vendors in the cluster for their various parts of pump manufacturing. Some of the parts produced in the cluster are Submersible Pump Sets, Submersible Motors, PVC pipes, Motor and Pump parts, Upper and lower adaptor and Impeller, CI parts and machining, Submersible spare parts and engineering and Machine tools. To promote the concept of LEAN and improve the productivity of company and across value chain, the following tools were utilized in the company: KAIZEN linkage with performance incentive, standard operating procedure (SOPs), automation, training of employees, daily works management, GEMBA Walk by owner every now and then and quality circle.

The major benefits realized after implementation were improved workplace with more space (nearly 15% improvement) and uncluttered work area. The concept "Place for Everything and Everything in its Place (PEEP)" initiated.

4.3 Case study 3: Packaging cluster

This cluster is located at Haridwar, Uttarakhand with a total of 10 units. This cluster deals with the MSMEs involved in developing packaging parts. Some of the products produced in this cluster are corrugated boxes, printed and non-printed mono cartons and corrugated rolls. The challenges identified by the consultant in the cluster were lack of records, no production planning and control, poor visual management, uneducated workforce, shortage of skilled workforce, poor maintenance of machines, high raw material inventory, high attrition rate and inconsistent demand from the customers. The model unit studied in this cluster was Patanjali Flexi Pack Pvt Ltd.

In this company to address the issues faced, the following methodology of Lean Management was adopted:

- Visual Improvement was implemented by Creating Factory within a factory by creating zone and zone leaders, sensing responsibility of ownership.
- Training at all levels – Directors, Managers and Supervisors, workers, all were trained to ensure horizontal deployment of all techniques taught for all value streams.
- Factory fundamental assessments in four areas – 5S, Visual Management, Asset Management, Kaizen were adopted.
- A model machine was developed to be used as a source of baseline data for all machines within the factory.
- A project on productivity improvement was also initiated.

Table 3 illustrates the tools adopted to initiate the above activities in the company.

After the Lean management implementation there has been a significant increase in the production with a significant increase in sales.

4.4 Case study 4: Auto cluster

This cluster was formed on the initiative of Minda Corporation Noida, for the implementation of lean methodology among the supply chain of approved vendors of MCL as Progressive Alliance of Competitive Enterprises (PACE) society, under the society registration Act. The cluster comprises 10-member units manufacturing automotive components. All the member units are either medium or small enterprises.

Some of the major issues identified by the consultant were high attrition rate among the workers, resource limitation, lack of faith in lean management tools by the top management and the changing mindset of the people. Some of the products produced in this cluster are sealing, o ring, gasket, rubber stopper, rubber bush, dirt seal, dust seal, lock barrel assembly-electrical & mechanical, compression spring, torsion spring, forming spring, conical spring, hook spring, screws, nut, bolt & washers, seal, latches, locking part, dust cover, mounting muffler, bushes, gromets and brackets.

Table 3 — Tools implemented in packaging cluster.

5S (Housekeeping)	Formation of zones and their teams along with zone leaders, proper gangways, markings on shop floor, cleaning, shining, painting across shop floor. A cross functional audit team to ensure continued sustainability.
Standard Operating Procedure (SOP's)	One Point Lesson sheets, Skill Matrix for value stream workers, general work instructions, SOPs for all departments excluding finance, management review matrix for review meetings.
Kaizen	In regard to KAIZEN, Kaizen gallery on Gemba (shop floor) and in office, culture of celebrating KAIZEN week, zone-wise competition on Best Lean Factory Fundamentals (LFF), regular audit of factory floor
Productivity	Productivity improvement project was undertaken with cycle time study through video recording, production plan and Gap analysis. The concept of Line balancing with special focus on waste elimination and measures for shift scheduling were undertaken. Value addition ratio and monthly trend tracking and Plant Layouts were created for comparison by top management.
Production Planning and Control	Production Planning and Control along with Inventory reduction for existing value streams was implemented. The stakeholders were taught to analyze material order and market order plan, shift planning and manpower planning. FIFO (First in and First out) hindrance identification and preparing inventory plan were also initiated.
Training	Extensive trainings, both classroom and factory floor were conducted with focus on Lean fundamentals, KAIZEN, productivity improvement, SOP and documentation, and Quality improvement tools.

The model unit in focus in this cluster is Astron Polymers Pvt Ltd. Astron Polymers is based out of Faridabad, Haryana and are engaged in manufacturing, supplying and exporting a wide range of molded rubber and plastic components. Their range includes Molded Rubber Components, Rubber Washers, Rubber Grommets, Rubber PVC Beadings, Rubber Plugs and Caps, Washing Machine Bellows and other similar products. As they are engaged with several international clienteles, lean manufacturing practices were cited as an important principle to be adopted in order to compete in the global market by the management.

Some of the steps adopted to improve performance and productivity were:

1. Basic structure, plant size, infrastructure available, current customer and product groups were assessed and implementation potential for the 18-month project was decided.
2. Selection of the product family for conducting Value Stream Mapping(VSM)[29] was carried out keeping in mind the major workstations that the majority of products pass through.
3. Value stream benchmarks were established to ensure proper tracking of progress and phase wise activity plans.

Provision of training to all to ensure Total Employee Involvement (TEI), visual management at shop floor, 5S at workplace through creation of Zones and Zone Teams, quality improvement process and total productive maintenance in terms of machine breakdown were some of the tools utilized in this cluster.

4.5 Case study 5 - OGTC lean cluster -1 – Textile sector

This cluster is situated in the National Capital Region of Delhi. It has a total 7 units in it. The cluster produces varieties of textile related products like men and women apparel, kids garment, jute apparel, embellished garments etc. This is a labour intensive sector. The major issues identified by the consultant in the SMEs in this cluster were related to Productivity, Quality, Wastage, Maintenance, Storage Inadequate MIS etc. which quite often resulted in delayed shipment and higher costs. 5S, Kaizen, value stream mapping, training of employees, Kanban, Daily Management Information System, SOPs, Vendor Management were some of the Lean Management Tools implemented. As a result there has been an improvement in quality, productivity, reduction of wastage, skill improvement, increased accountability of the materials and reduction in machine has been realized. The summary of lean implementation outcomes for this cluster is indicatedin Table 4.

4.6 Case study 6: TTPK knit garment cluster

This cluster is Knit Garment Cluster located at Tirupur, Tamil Nadu that is the southern part of the country. There are totally 6 units in this cluster. The cluster specializes in producing men, women and kids knitted garments. The four major challenges identified in this cluster were weak material accountability, delayed shipment, high inventory levels and lack of data based decision making. To address these issues the lean management principles of 5S, creation of zones and zone teams, Kaizen, training, quality control were implemented (Fig. 5).

Table 4 — Study of return on consultant fee realized in 347 MSME units (43 clusters) after completion of lean implementation cycle [P&M : Plant and Machinery].

Scale	Units	Average Investment in P&M (₹ Cr)	Total Consultant Fee (₹ Cr)	Total Savings (₹ Cr)	Consultant Fee Per Unit (₹ Lakhs)	Savings Per Unit (₹ Lakhs)	Returns on Consultant Fee (Ratio)
	A	B	C	D	E = (C/A)	F = (D/A)	G = (F/E)
Micro	59	0.14	2.02	7.64	3.43	12.95	3.77
Small	255	1.94	8.69	75.49	3.41	29.60	8.69
Medium	33	7.46	1.12	15.23	3.38	46.15	13.65
TOTAL	347	₹ 2.16	₹ 11.83	₹ 98.36	₹ 3.41	₹ 28.35	8.32

Fig. 5 — Glimpse of lean implementation in garments cluster.

After implementation some of the benefits realized in the cluster were systematic methods of disposal of waste materials and cleaning, material accountability and defect control, reduction of clutter in workplace, reuse of saved space etc.

In the six units of the cluster, implementation of lean management lead to increase in quality, reduction in lead time, reduction of inventory and wastage, reduction in fabric buffer allocation, increase in on-time delivery of the products (by 26%), reduction in defects (by 73%) and overall total employee involvement (Fig. 6).

The overall productivity in all the units in the 43 clusters that had implemented the lean management had increased to an average of 27% in a

span of 18-24 months. The cost invested in hiring consultants for leading the process and training the employees were recovered in the savings made through increased productivity (Table 4).

It was observed that post implementation of Lean in an average span of 18-24 months an average 8.32 times returns on consultant fee has been achieved by the organizations. Moreover, the completed clusters have realized an average of ₹28.35 lacs per unit after completing lean interventions in the units. It was observed that each organization had selected various Lean Implementation Tools based on the review of challenges faced pre-implementation, the performance parameters/ benefits targeted post implementation, availability of the resources (time, cost, schedule, day to day activities etc.) and existing manpower number and characteristics The common implementation challenges faced during Lean implementation as expressed by the consultants are lack of awareness among the employees regarding Lean processes, confusion related to validity of the benefits to be realized, resistance to change the existing way of working and lack of time.

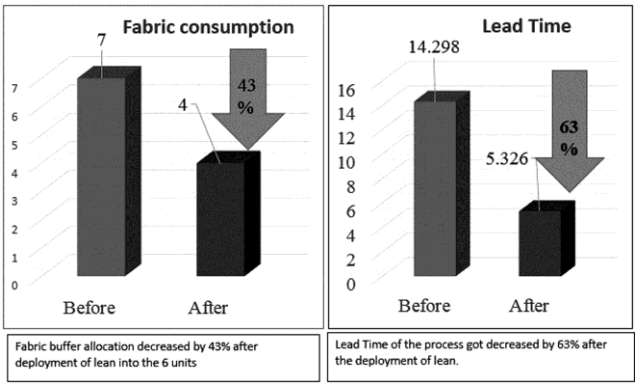

Fig. 6 — Benefits realized in garments cluster.

4.7 Validation study of assessments of lean clusters by the NMIU team

Totally 24 units from various clusters were assessed over 9 parameters on a score of 5 each (Table 5). The units in the clusters were assessed based on their awareness to the scheme, number of visits made by the consultant, perception of the owner on the consultant performance, views of the consultant on the unit performance, owners perception of the benefits realized, their view on NMIU etc. Table 5 highlights the average scores achieved by all units on different parameters set up for evaluation of clusters: It resulted in an average satisfaction score of 88.28% on implementation of Lean tools and techniques in the clusters. Table 6 provides a summary of the implementation in the textile cluster.

5 Discussions

The six case studies highlighted some of the problems that commonly existed in all the sectors before implementing lean management principles, challenges during implementation and benefits realized based on the implementation. Workforce related challenges like lack of skills, lack of

Table 5 — Average scores of all clusters assessed based on NMIU validation assessment.

S. No.	Assessment Parameters	Number of Units scoring 1 out of 5	Number of Units scoring 2 out of 5	Number of Units scoring 3 out of 5	Number of Units scoring 4 out of 5	Number of Units scoring 5 out of 5	TOTAL Number of Units	Average Score out of 5
1	Unit Awareness Of the Scheme			5	9	10	24	4.21
2	Visits by (1D) Consultant (Continuity of Lean Expert Visit)			5	6	13	24	4.33
3	Owners View on Consultant Performance (Tangible Benefits achieved)			2	10	12	24	4.42
4	Coordinators/ Owners View on Consultant Performance			2	5	17	24	4.63
5	Consultants View on the Unit performance			1	7	16	24	4.63
6	Documentation at Unit for Lean Implementation			5	10	9	24	4.17
7	Owners view of NMIU - Quality Council Of India			1	10	13	24	4.50
8	Consultant View of NMIU - Quality Council Of India				7	17	24	4.71
9	Overall feel of the Unit (Lean Intervention)			3	15	6	24	4.13

OGTC Lean Cluster I

Table 6 — Summary of lean implementation outcomes in textile cluster

Sr No	Lean Project (Indicative List)	Metrics	Cluster Units							Total
			1	2	3	4	5	6	7	
1	Training	Programs (No's)	7	7	7					
2	5 S	Value (Rs)	₹ 4,300.00	₹ 7,85,000.00	₹ 77,000.00	₹ 11,43,000.00		₹ 1,83,720.00	₹ 12,68,000.00	₹ 34,61,020
3	Cellular Layout (Single Piece Flow)	Efficiency (increased by)	15%				50%			
		Value (Rs)	₹ 9,60,000.00	₹ 13,50,000.00						₹ 23,10,000
4	Value Stream Mapping	Manpower Utilization (reduced by)	25%		25%					
		Value (Rs)	₹ 4,10,00,000.00	₹ 1,06,08,000.00	₹ 4,84,800.00	₹ 10,80,000.00	₹ 11,23,200.00	reduction of 2 process and reduce the handing of the finished goods	Reduction of 3 process to reduce the transportation, inventory and manpower in new facility	₹ 5,42,96,000
		Space Saving (Sq Ft)				833				
5	Kaizen	Value (Rs)	₹ 52,38,800.00	₹ 19,76,000.00	₹ 62,420.00	₹ 5,48,000.00	₹ 10,84,283.00	₹ 39,73,642.00	₹ 1,48,59,130.00	₹ 2,77,42,275
6	Change Over Time	Value (Rs)	₹ 7,21,912.00	₹ 1,50,48,000.00			₹ 6,22,781.00	₹ 2,88,000.00	₹ 34,60,320.00	₹ 2,01,41,013
		Time (reduction in hours)	10 hours				5 hrs		20 hrs	
		Efficiency (improvement)		15%						
7	Kanban System	Reduction in WIP	1000 pcs	1000pcs						
		Reduction in Rejection %		4%						
8	Daily management Information systems implementation.				√	√	√	√	√	
9	Formats Standardization				√		√		√	
10	Vendor Management	Reduction in DHU %				3%				
11	Planning Control & Merchant					√				
12	Skill Matrix and New Operator Appointment							√		
13	SOP and KPI For Model area							√		
14	Poka Yoke								√	
15	Visual Management	Activities			√	√			√	
16	Total Productivity Maintenencae (TPM)	Reduction in Breakdown Time	50%	36%	47%		73%	Reduced breakdown time, from 2 hours to almost zero.		
Total			₹ 4,79,25,012.00	₹ 2,97,67,000.00	₹ 6,24,220.00	₹ 27,71,000.00	₹ 28,30,264.00	₹ 44,45,362.00	₹ 1,95,87,450.00	₹ 10,79,50,308.00

motivation and careless attitude, wastage of materials and resources, improper material management, lack of management and leadership all resulted in considerable loss of money, production and decreased quality. All this necessitated implementation of lean skills and techniques, change in leadership behaviour, engagement of the employees and organization wide education. This resulted in all the MSMEs an inculcation of basic culture for work place effectiveness and elimination of waste, strain and discrepancy elimination. Such change in leadership behaviour, engagement of employees and education have been accepted as the basic strategy for successful implementation of lean tools, technologies and processes[27,30-35]. A system for planning and implementation of 5S as per the plan in all plant areas, offices, project site, and offsite offices step-by-step was in place. Training employees and service providers on occupational health and hygiene, safety and environmental related issues was a regular part in all the units. Equipment related safety e.g. safety control system, guards/ protections etc., was ensured. A system for recording of all accidents near misses and dangerous occurrences was established. A system for continuous improvements (Kaizen) was put in place and involvement of all employees was ensured. Evaluating, recognizing and rewarding Kaizens, best theme etc. was periodically performed.

To improve quality a comprehensive and systematic appraisal of the manufacturing system including products and processes was carried out. Each unit established a system for supplier development that included selection, appraisal etc. Calibrated measurement devices with required accuracy and range were made available. An appropriate production planning and scheduling system was implemented. Every opportunity to reduce manufacturing cycle time to reduce work in process inventory was utilized and bottlenecks for delivery performance including transportation capacity, quick turnaround time were identified. On-time in Full-Delivery for all the customers was measured and monitored to arrive at improvement points to achieve targets. Inventory was maximized using approaches like revising min- max levels, eliminating the obsolete items, direct on-line delivery etc.

Productivity metrics in every area including non-manufacturing like calculation & balance of TAKT time (rate at which a finished product needs to be completed in order to meet customer demand Time), implementation of low cost automation and deployment of self-maintenance practices has been initiated.

Literature emphasizes that management commitment[27,36] and adoption of digital technologies[37] is vital for lean management. Adoption of technologies like big data analysis, cobots, sensors, artificial intelligence etc., lead to real time decision making and smart production (Fig. 7).

But this mandates that the lean manager understands what they need to implement. They should be keen to learn and be part of the system to bring about the change in their team. This could be seen in all the case studies highlighted in the study that formation of Zone units with the team leader/ zone leader actively participating, taking initiative to bring about change and motivating employees. They supported the implementation by management by observation by walking around the plants, taking part in planning and by interacting frequently with the team. With their cooperation and support the teams were able to reduce wastage, improve quality of the products and increase on-time production of the units. This further increased the confidence of the employees and also helped in leveraging their identity for successful lean implementation.

Earlier study had identified that significant barriers to lean management implementation in Indian MSMEs were little support from top management, resistance to change the middle management, poor lean training and absence of lean implementation team[38]. In all the MSMEs studied, it was observed that support from management, providing training to the employees and having a lean implementation team were some of the critical factors that helped in successful implementation.

Based on interaction with the owners of the MSMEs it is perceived that the duration for implementation of LMCS should be increased to a minimum 24 months to be more effective. Online LMCS portal needs to be upgraded to make it more users friendly and easier to navigate through various uploaded reports. Further it is recommended that frequent audits need to be conducted in the units participating in the scheme for better implementation. Moreover, simplifying document formats, encouraging inter cluster activities like sharing best practices, learning etc. can further help in successful implementation of the lean management scheme. Quantitative and qualitative assessment reviews of participating units can provide further monitoring of the implementation process.

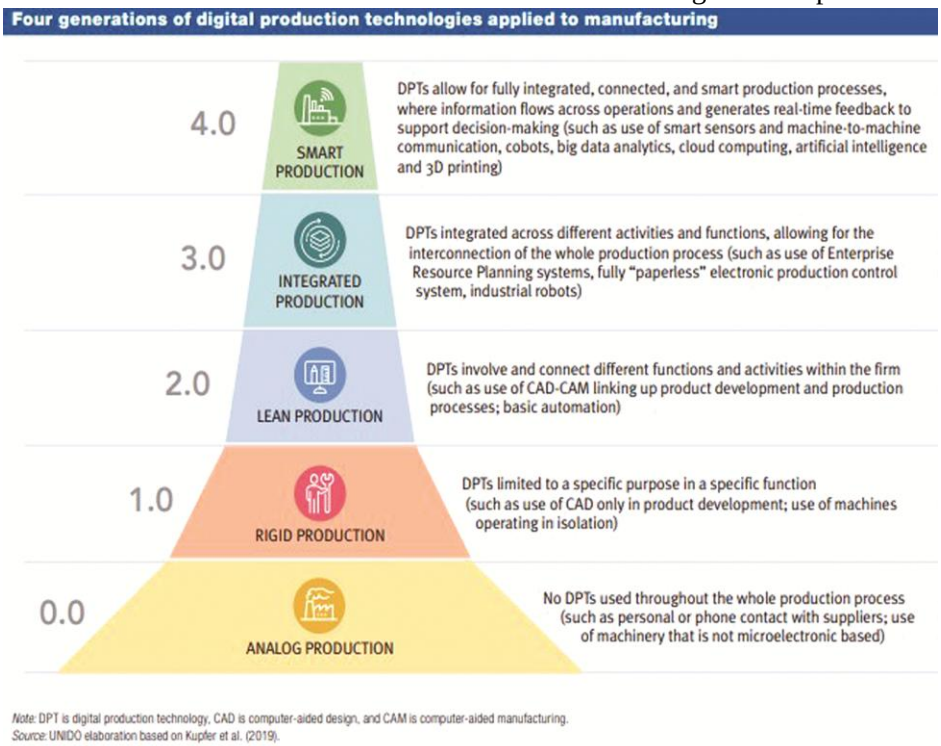

Fig. 7 — Four generations of digital production technologies (DPT) applied to manufacturing production[38].

6 Conclusions

Many MSMEs in India are not fully aware of lean management principles. The thought of Kanban, Just-in time or any other lean principles used by larger companies puts a fear in the smaller firms. Many may be using lean principles without being aware. They lack the knowledge and the management skills needed to implement lean management techniques and they do not have the resources to hire skilled personnel who could help them make the change. The lean management scheme implemented through Govt of India, has proven to be one of the progressive schemes and has helped to overcome the above-mentioned barriers. With the financial and human resource support provided through the scheme, the MSMEs have been able to appoint consultants to guide them in implementing the lean management process in their units. Lean methodology has been implemented in loss making units as well. It has been observed that after implementation of lean tools and techniques, the units have been able to generate profits in a time span of 12 -18 months. Moreover, as mentioned earlier their productivity in units have also increased. Lean manufacturing techniques are proven world-wide, however MSMEs are still unaware and wary of contributing 20% of the consultant fees for realizing the benefits. The money spent for hiring a consultant has been compensated significantly and has resulted in enhanced profit realization. Further, MSMEs in a cluster are wary of sharing the best practices amongst each other towards apprehension of losing their edge of unique manufacturing practices to their competitors in the market. Further intangible benefits realized has been reduction in wastage, increased customer satisfaction, organized supplier and vendor management, increased employee efficiency and involvement, increased quality of the products, reduced lead times, reduced space requirements, increased overall equipment effectiveness and reduced production costs .The same has also been reflected by the validation check conducted randomly through site visits of 23 MSME units by the NMIU committee.

Other benefits realized were optimization of inventory, reduction of manufacturing lead time, increase in machine availability, reduction of time in material transportation, percentage reduction in defects of parts per million (PPM), decrease in yearly breakdown time, 5S score increase, savings in energy and improvement in on time delivery. Besides above, continuous improvement through improved employee turnover and introduction of daily work management with daily targets has shown reduction in overtime, leading to improvement in work life balance. Further, the implementation of Lean tools and techniques such as 5S, Kaizen, Visual Control, SOP etc. has led to realization of significant worker safety along with freeing up of workspace. All these establish that the up-scaling of lean manufacturing technique practices is required across the entire MSME sector pan India quickly to stay competitive in the global markets.

Based on the quality maturity model in manufacturing[37], post implementation of lean brings in stability, manufacturing based on Pull (Demand) requirements and stable processes. MSMEs can then move forward towards Digital Production Technologies (DPT)[39] capability for attaining resource optimization in production besides culture of continuous innovation and quality enhancements.

In conclusion, this study establishes that up-scaling of 'Lean Manufacturing Technique practices' is required en-masse across the entire MSME sector quickly so that they can realize the benefits of Lean and step up to invest in sustainable Industry 4.0 tools[40] leading to advanced digital production (ADP)[41] techniques, essential for maintaining competitiveness in the industry today. The data driven smart manufacturing would enable the MSMEs to maintain competitiveness in the global markets through innovation and internationalization, resource optimization and flexible manufacturing.

As a way forward, a quantitative and qualitative survey of various stakeholders' viz. senior managers, middle managers, implementers, employees, suppliers and customers would provide deep insight of the problems and challenges associated with implementation and help to develop a model of implementation specific to the industry. Competitiveness of MSMEs are key to their survival that can be achieved through implementation of Lean; investment in technology up gradation; enhancement of efficiency and resource optimization leading to increased value proposition, growth in their sector, and furtherance of employability.

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