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Toyota Production System (TPS) – Applications and Benefits for Indian Pump and Motor Manufacturing Industry: A Case Study

Siddharth Pal
Assistant Director, Department of Industrial Engineering, National Productivity Council, Gandhinagar, India

***Abstract*: The Toyota Motor Corporation is one of the top automobile manufacturers in the world and behind its success is the Toyota Production System (TPS). TPS is a philosophy based on continuous improvement and eliminating waste in processes and in the space where work is performed. At the center of this philosophy is the emphasis on learning. Although several companies attempt to implement the methods and tools of TPS, many do not understand the learning organization culture that must be developed to support it.**

This case study reveals the need of Toyota Production System (TPS) in Micro Small & Medium Enterprise (MSME) Clusters under Lean Manufacturing Competitive Scheme for Indian Pump & Motors Manufacturers Association (IPMA) of Ahmedabad of which monitoring and evaluation done by National Productivity Council (NPC) and implementation was carried out by Add Value Consulting, under the Lean Manufacturing Competitiveness Scheme (LMCS) of Gujarat.

***Keywords*: Lean, TPS, Six Sigma, Micro Small Medium Enterprise (MSME's), Pump and Motor**

1. Introduction

The term Lean in the manufacturing environment also refers to the Toyota Production System (TPS) established by the Toyota Corporation. Within the organization, four prominent gentlemen are credited with developing the system: Sakichi Toyoda, who founded the Toyoda Group in 1902; Kiichiro Toyoda, son of Sakichi Toyoda, who headed the automobile manufacturing operation between 1936 and 1950; Eiji Toyoda, Managing Director between 1950 and 1981 and Chairman between 1981 and 1994; and Taiichi Ohno, the Father of the Kanban System.

Manufacturers are under tremendous pressure to improve productivity and quality while reducing costs. This has led many organizations to implement the Toyota Production System (TPS), otherwise known as lean manufacturing (Liker, 2004; Womack, 2003). Thus, it seems to be important to gain an understanding of how TPS relates to other methods for improving manufacturing systems including Green Manufacturing and quantitative analysis performed using tools such as mathematical optimization and discrete event simulation. In this regard, validation evidence for two premises is sought through a case study at a small furniture production company.

- TPS (Lean Manufacturing) transcends Green Manufacturing, that is, a lean transformation of a production facility will likely result in a green transformation as well.
- The application of quantitative analysis tools such as mathematical optimization and discrete event simulation makes a lean transformation more precise and thus leaner.

A. Goals of Toyota Manufacturing System (TPS)

The main objectives of the TPS are to design out overburden (muri) and inconsistency (Mura), and to eliminate waste (Muda). The most significant effects on process value delivery are achieved by designing a process capable of delivering the required results smoothly; by designing out "Mura" (inconsistency). It is also crucial to ensure that the process is as flexible as necessary without stress or "muri" (overburden) since this generates "Muda" (waste). Finally, the tactical improvements of waste reduction or the elimination of Muda are very valuable. There are eight kinds of Muda that are addressed in the table 1.

Table 1
Eight Deadly Wastes

Waste	Description
Over Production	Producing more than needed
Transportation	Excessive movement of materials
Inventory	Excessive Inventory
Motion	Excessive motions/ movement
Over-Processing	Processing more than required
Waiting	Waiting longer for the material or next operations
Defects	Non conformance
Human Resources	Excessive manpower for a required job

The elimination of Muda has come to dominate the thinking of many when they look at the effects of the TPS because it is the most familiar of the three to implement. In the TPS many initiatives are triggered by Mura or muri reduction which drives out Muda without specific focus on its reduction.

2. Introduction to Lean Manufacturing

Lean is the concept of efficient manufacturing / operations that grew out of the Toyota Production System in the middle of the 20th century. It is based on the philosophy of defining value from the customer's viewpoint, and continually improving the

way in which value is delivered, by eliminating every use of resources that is wasteful, or that does not contribute to the value goal. Lean is centered on preserving value with less work; with the ultimate goal of providing perfect value to the customer through a perfect value creation process that has zero waste. This is done by empowering every individual worker to achieve his or her full potential, and so to make the greatest possible contribution.

The goal of empowerment is based on the idea of showing respect for people. Respect for people extends beyond just the end customer and can include the workers, suppliers, and society. For the end customer, Lean strives to maximize value delivery while minimizing waste in the process. Lean aims to maximize human potential by empowering workers to continuously improve their work. Lean leaders facilitate this goal through problem-solving training. They help workers grow professionally and personally, allowing them to take pride in their work.

At the heart of the Lean philosophy is the concept of "kaizen" or continuous improvement. The goal of continuous improvement is to eliminate all waste in the value delivery process. To do this, Lean leaders must go where value is created – commonly known as the gemba. At gemba, they often spend their time coaching and developing their people. They encourage workers to actively identify problems and look for opportunities for improvement.

Originally Lean Manufacturing was known as "Just-In Time Production" it builds on the approach created by the founder of Toyota, Sakichi Toyoda, his son Kiichiro Toyoda, and the engineer Taiichi Ohno.

The founders of Toyota drew heavily on the work of W. Edwards Deming and the writings of Henry Ford. When these men came to the United States to observe the assembly line and mass production that had made Ford rich, they were unimpressed. While shopping in a supermarket they observed the simple idea of an automatic drink re supplier; when the customer wants a drink, he takes one, and another replaces it. The principles underlying the TPS are embodied in The Toyota Way.

3. Origin of Lean Manufacturing

Lean thinking originated at Toyota with the Toyota Production System (TPS). The original ideas were formulated by Sakichi Toyoda in the 1920s and 1930s. Taiichi Ohno began to implement these ideas in the 1940s but only made the leap to full implementation in the 1950s. Many of the principles of lean came from a surprising source: American supermarkets where small quantities of a vast selection of inventory are replenished as customers "pull" them off the shelf. This is the Kanban system. The hardest part of learning to think lean is abandoning old ideas about economies of scale and mass production. These are basically "push" systems based on projected customer demand. Quality is "inspected" into the product. These "batch and- queue," push system ideas must be the first casualties of the lean transformation. In lean, quality, productivity and low cost come from producing small batches (ideally one) of a given product, start-to-finish without any piles of partially finished goods. The principles of lean are pretty simple, whether you apply it to manufacturing, service, or administration.

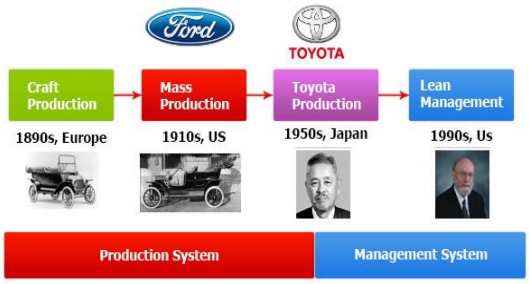

Fig. 1. Origin of lean manufacturing

4. Origin of Six Sigma

Six Sigma was launched by Motorola in 1987. It was the result of a series of changes in the quality area starting in the late 1970s, with ambitious ten-fold improvement drives. The top level management along with CEO Robert Galvin developed a concept called Six Sigma. After some internal pilot implementations, Galvin, in 1987, formulated the goal of "achieving Six Sigma capability by 1992" in a memo to all Motorola employees. The results in terms of reduction in process variation were on track and cost savings totaled US$13 billion and improvement in labor productivity achieved 204% increase over the period 1987–1997.

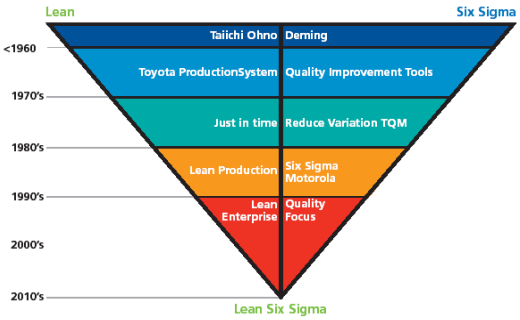

Fig. 2. Lean six sigma

In the wake of successes at Motorola, some leading electronic companies such as IBM, DEC, and Texas Instruments launched Six Sigma initiatives in early 1990s. However, it was not until 1995 when GE and Allied Signal launched Six Sigma as strategic initiatives that a rapid dissemination took place in non-electronic industries all over the world (Hendricks and Kelbaugh, 1998). In early 1997, the Samsung and LG Groups in Korea began to introduce Six Sigma within their companies. The results were amazingly good in those companies. For instance, Samsung SDI, which is a company under the Samsung Group, reported that the cost savings by Six Sigma projects totaled US$150 million

(Samsung SDI, 2000a). At the present time, the number of large companies applying Six Sigma in Korea is growing exponentially, with a strong vertical deployment into many small- and medium-size enterprises as well.

5. Combination of Lean and Six Sigma

Lean Manufacturing focuses on reducing cycle time and increasing process speed. Its goal is the removal of non-value added process steps or time traps from the process. Lean is a great method to help organize work areas, reduce WIP (Work-In-Process), and speed material flow through the entire manufacturing process. Successful Lean initiatives yield lower inventory cost, higher productivity and flexibility, and faster response time to the customer.

Six Sigma is a statistical quality goal that represents the achievement of a quality level equal to no more than 3.4 defects per million opportunities. For most companies, this is a significant if not radical improvement in quality. But Six Sigma is more. It also focuses on reducing defects and variability within a formalized project management structure. In fact, the management structure for executing and managing projects is a real strength of the Six Sigma approach. When executed well, Six Sigma can help an organization achieve very significant improvements in quality, reduction of defects, and ultimately lower cost. Six Sigma is not only for manufacturing, but any operation where an opportunity exists for error, including order entry, customer service, sales, HR, etc.

6. Objective of the Study

1. To understand tools and techniques adopted in lean management.
2. To know whether the lean management helps to improve productivity and reduction in cost.
3. To identify the major challenges in implementation of Lean management in Indian MSMEs.

From the above review of literature, it is clear that very few researches has been done pertaining to study of challenges in implementation of Lean. Current study is conceptual in nature and all the data collected for analysis is from secondary sources (i.e. Closure report, MBR and MSME Unit)

Scope of the Study: This present study confines only with challenges faced by Indian MSMEs of Pump & Motor in implementation of Lean management and the benefits in productivity and cost savings.

7. Objective-1: To understand tools and techniques adopted in lean management by LMC

This study is research work of the Lean implementation carried out at Indian Pump & Motor Cluster, Ahmedabad by Lean Manufacturing Consultant (LMC).

A. 5 'S'

Is all about organizing the work area:

- Sort (eliminate which is not required)
- Set in Order (organize items)
- Shine (clean work area)
- Standardize (standards for above)
- Sustain (Maintain standards)

Table 2
Various Lean Techniques Adopted

5 'S'	Poka-Yoke (Error Proofing)
Andon (Visual Notification)	Single Minute Exchange of Dies (SMED)
Just in Time (JIT)	Total Productive Maintenance (TPM)
Heijunka (Level Scheduling)	Value Stream Mapping (VSM)
Hoshin Kanri (Policy Deployment)	Visual Factory
Jidoka (Automation)	Standardized Work
Kaizen (Continuous Improvement)	Root Cause Analysis
Kanban (Pull System)	Key Performance Indicators (KPI)
Muda (Waste)	Plan-Do-Check-Act (PDCA)
Overall Equipment Effectiveness (OEE)	

- *Sort:* Clearing the work area — Any work area should only have the items needed to perform the work in the area. All other items should be cleared (sorted out) from the work area.
- *Set in Order:* Designating locations — Everything in the work area should have a place and everything should be in its place.
- *Shine:* Cleanliness and workplace appearance — not only should the work area be clear, it should also be clean. Cleanliness involves housekeeping efforts, improving the appearance of the work area, and even more importantly, preventive housekeeping — keeping the work area from getting dirty, rather than just cleaning it up after it becomes dirty.
- *Standardize:* Everyone doing things the same way — Everyone in the work area and in the organization must be involved in the 5S effort, creating best practices and getting everyone to "copy" those best practices the same way, everywhere, and every time. Work area layouts and storage techniques should be standardized wherever possible.
- *Sustain:* Ingraining the 5Ss into the culture — it is tough to keep a 5S effort, or any improvement effort for that matter, going. The 5Ss involve a culture change. And to achieve a culture change, it has to be ingrained into the organization — by everyone at all levels.

This will help in Eliminating waste those results from a poorly organized work area (e.g. wasting time looking for a tool).

1) Andon

Is a visual feedback system for the shop floor that indicates production status, signals when assistance is required, and authorizes operators to stop the production. It acts as a real time communication tool for the shop floor that conveys immediate attention to problems as they occur, so that it can be immediately addressed.

2) Just In Time (JIT)

Pull parts through production based on demand from customer instead of pushing parts through production based on demand projected. Depend on various lean tools such as Heijunka, Takt Time, Continuous Flow, Standardized Work and Kanban. It is highly effective in reducing inventory levels. Improves cash flow and reduces space requirements.

3) Heijunka (Level Scheduling)

A system of production scheduling that deliberately manufactures in smaller batches by sequencing (mixing) product alternatives within the same process. It reduces lead time (since each product or variant is manufactured often) and inventory (since batches are smaller).

4) Hoshin Kanri (Policy Deployment)

Aligning the goals of the company (Strategy), with the plans of middle management (Tactics) and the work performed on the plant floor (Action). It Ensures that progress towards strategic goals is consistent and thorough – eliminating the wastes that originates from poor communication and inconsistent direction.

5) Jidoka (Automation):

Design equipment's to partially automate the manufacturing process (partial automation is much less expensive than complete automation) and to stop automatically when defects are detected. After Jidoka, workers can regularly monitor multiple stations (reducing labour costs) and many quality issues can be addressed immediately (improving quality).

6) Kaizen (Continuous Improvement)

Is a strategy where employees work together in proactive manner to achieve regular, sustainable and incremental improvements in the manufacturing processes. It combines the collective talents of a company to create an engine that will continually eliminate waste from manufacturing processes.

7) Muda (Waste)

Anything in the manufacturing process, that does not add value from the customer's perspective. Muda means 'waste'. The elimination of wastage i.e., Muda is the primary focus of lean manufacturing.

8) Kanban

Kanban is a Japanese word that means "instruction card". Kanban's are manual pull devices that allow an efficient means to transfer parts from one department to another and automatically reorder products using minimum/maximum inventory levels. A Kanban is a signal, such as an empty container returned to the start of the assembly line, which signals the need for replenishment of materials to a user.

9) Overall Equipment Effectiveness (OEE)

Framework for determining productivity loss for a specified manufacturing process. Three classes of loss are tracked:

1. Availability (e.g. down time)
2. Performance (e.g. slow cycles)
3. Quality (e.g. rejects)

It provides a benchmark and a means that tracks progress in eliminating wastes from a manufacturing process. 100% OEE means faultless production (manufacture of only good parts, as fast as possible, with no down time).

B. Poka-Yoke (Error Proofing)

Design error detection, and prevention into production processes with the goal of achieving zero defects. It is not a very simple task in identifying all defects through inspection, and correcting defects typically gets significantly more expensive at each stage of production. Hence, Poka-Yoke will be helpful in this regard, where each product is checked in all the process before going to further process.

1) Single-Minute Exchange of Dies (SMED):

Reduce setup (changeover) time to less than 10 minutes. Techniques include:

- Convert setup steps to be external (performed while the process is running).
- Simplify internal setup (e.g. replace bolts with knobs and levers).
- Eliminates non-essential steps or operations
- Creates Standardized Work instructions and enables manufacturing in smaller lots, reduces inventory, and improves customer responsiveness.

2) Total Productive Maintenance (TPM)

A holistic approach in maintenance that focuses on proactive and preventative maintenance to take full advantage of the operational time of equipment. TPM shapes the difference between maintenance and production by placing a strong emphasis on empowering operators to help maintain their equipment. It creates a shared responsibility for equipment that encourages greater involvement by shop floor workers. In the right environment, this can be very effective in improving productivity (increasing up time, reducing cycle times, and eliminating defects).

3) Value Stream Mapping

A tool, which is used to visually map the flow of production. Shows the current and future (FSVS/VSD) state of processes in a way that highlights opportunities for improvement. It Exposes wastes in the current processes and provides a roadmap for improvement through the future state.

4) Visual Factory

A tool similar to Andon but this uses visual indicators, displays and controls used throughout the manufacturing plant to improve communication of any information. It makes the state and condition of manufacturing processes easily accessible and very clear to everyone.

5) Standardized Work

Documented procedures for manufacturing that capture best practices (including the time to complete each task). Must be "living" documentation that is easy to change.

6) Root Cause Analysis

A problem solving methodology that primarily focuses on resolving the underlying problem instead of applying readymade solutions that only treat immediate symptoms of the problem. A usual approach is to ask why five times – each time moving a step closer to discovering the true underlying problem. It ensures that a problem is eliminated by applying corrective action to the "root cause" of the problem.

7) KPIs (Key Performance Indicators):

Metrics are designed to track and encourage progress towards critical goals of the organization. Strongly endorsed KPIs can be extremely powerful drivers of behavior – so it is important to carefully select KPIs that will drive desired behavior.

The best manufacturing KPIs are:

1. Aligned with strategic goals framed by top-level (thus helping to achieve those goals).
2. Effective at exposing and quantifying waste (Example OEE).
3. Influenced by plant floor employees (so they can drive results)

8) Plan Do Check and Act (PDCA):

An iterative practice for implementation of improvements:

- Plan (establish strategy and expected outcomes)
- Do (implement plan)
- Check (verify expected results achieved)
- Act (review and assess; do it again)

It applies a scientific approach in making improvements:

- Plan (develop a hypothesis)
- Do (run experiment)
- Check (evaluate results)
- Act (refine your experiment; try again)

8. Objective-2: To know whether the lean management helps to improve productivity and reduction in cost for MSME units

The Development Commissioner, Ministry of Micro, Small & Medium Enterprises (DC-MSME), Govt. of India, implemented up-scaled „Lean Manufacturing Competitiveness Scheme (LMCS)", for the benefit of Micro, Small & Medium Enterprises (MSMEs) during the 12th Five-year plan, after successful completion of the Pilot Phase. The scheme will be implemented in 500 mini clusters during 12th Five Year Plan with the total Project Cost of Rs. 240.94 crores (Govt. of India Contribution amounting to Rs. 204.94 cr. and beneficiaries" contribution of Rs 36.00 cr.) including expenditure on remaining part of the pilot phase of the scheme for the year 2013-14.

Lean Manufacturing Competitiveness Scheme (LMCS) is applicable to only Micro, Small and Medium enterprises. The MSME units should be registered with District Industries Center (DIC) or with any other agency (professional body, association, government agency, department, etc.) to get the benefit under this scheme. It is implemented in the form of Mini clusters having units of minimum 6 units and maximum 12 units producing similar products and located within an identifiable and as far as practicable, contiguous area. The implementation of the scheme is done by the Lean Manufacturing consultants by the MSMEs. A tri-partite agreement, would be signed by the mini-cluster representative, NPC and the Lean Manufacturing Consultant. This agreement contains all the terms and conditions, phase wise amount to be paid, roles of all parties, etc.

For MSME units under Indian Pump Manufacturing Association, Ahmedabad (IPMA) cluster seeking to get a sustainable decrease in costs, the optimization of key processes is essential.

In this context, Lean Manufacturing Consultant (LMC) implemented the Lean Manufacturing (LM) approach, based on continuous improvement, as a cost-saving solution, focused on methods to reduce costs without compromising safety, environmental sustainability and capital budgets. Following the deployment of excellent processes through specific instruments and methodologies, the Pump & Motor Manufacturing units can make rapid progress towards measurable improvements.

An initial analysis involves identifying Key Value Levers that can be used in reducing operating costs and achieving sustainable performance. Some of them are listed in Table 1, together with a potential range of opportunities for improvement. Cost reduction and its optimization require the elimination of any unnecessary practice that does not add value to the process. Thus, the management of flow values is a way of concentrating all efforts towards achieving the appropriate objectives by allocating the resources for those activities which bring new value.

For Indian Pump Manufacturing Association (IPMA) Lean Cluster under Lean Manufacturing Competitiveness Scheme (LMCS). Following organizations had taken part in it and lean implemented over a period of 18 months:

1. Sabar Pumps Pvt. Ltd.
2. NESA Pumps Pvt. Ltd.
3. Saga Windel Pumps Pvt. Ltd
4. Veer Electronics
5. Unnati Mech Pvt. Ltd.
6. MBH Pumps Gujarat Pvt. Ltd.
7. TECHNO Industries Ltd.
8. La-Gajjar Pumps Private Ltd.
9. Niki Pump
10. VGOR Engineers

The cost benefits realized after 18 months of lean implementation for each pump & motor units were plotted in below chart.

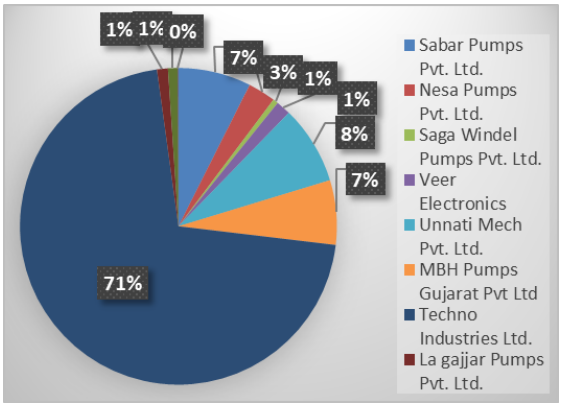

Fig. 3. Overall cost savings in % of IPMA units

9. Objective-3: To identify the major challenges in implementation of Lean management in Indian MSMEs.

Challenges in Lean management implementation in Indian Context-The purpose of Lean management is to support the business goals. It asks for the change from traditional process of working to a method that motivates business excellence practice. This all requires big changes to happen within the organization system; starting from change of management thought process, balanced deployment of resources, allocation of funds, and training of staffs, etc.

According to previous studies, a variety of challenges in implementation of Lean management has been discussed. Some of them are related closely to technical, cultural, organizational and economic factors to the implementation of Lean management in companies. Even though Lean management is an established structure for improving the organization in all aspects but still most of the MSMEs faces more complications in implementation of Lean management. Lean production has been in India for more than twenty years but only a countable number of companies have successfully adopted Lean and are able to make considerable success out of it.

The intention of this paper is to observe the challenges and ascertain ways for effective implementation of Lean based on the study in the Indian MSMEs. Top-level management issues for lean implementation is also very important and top-level management policies and attitude towards lean implementation need some improvement in Indian industries. Individual challenges of Lean implementation have been identified and classified into four major categories.

A. Management issues.
B. Organizational issues
C. Finance issues
D. Other issues

A. Under Management issues, challenges of lean implementation are

1. Lack of Management Focus
2. Lack of Management Support
3. Lack of Capital Fund
4. Lack of Implementation of Know-How
5. Lack of Long Term Vision
6. Past Experience of Failure
7. Lack of Need to Create Sense of Urgency

B. Under Organizational issues

1. Lack of Labor Resources
2. Company Culture
3. Lack of Innovative Ideas
4. Lack of Communication
5. Lack of Time
6. Lack of Training
7. Lack of Understanding about Lean
8. Clashes with Other Initiatives like TQM, TPM, JIT, etc.
9. Different Manufacturing Environments

C. Finance issues

1. Perceiving lean will cost more and is largescale companies.
2. No financial targets and sliding back to former state in the absence of staying power.
3. No Immediate Financial Advantage
4. Not Recognizing Financial Benefits

D. Other issues

1. Unstable Demand
2. Conflicts with ERP Implementations
3. Middle Management Resistance
4. Employees Resistant to Change

10. Conclusion

The competitiveness of manufacturing MSMEs is vital for the Indian economy. Lean philosophy has proven to be a viable and popular approach for developing production processes and enabling continuous improvement in these companies. Despite a great interest among academics and practitioners, more empirical research on lean manufacturing development in Indian MSMEs are needed.

Study of a lean development project in an Indian-based manufacturing MSME cluster (Pump & Motor).

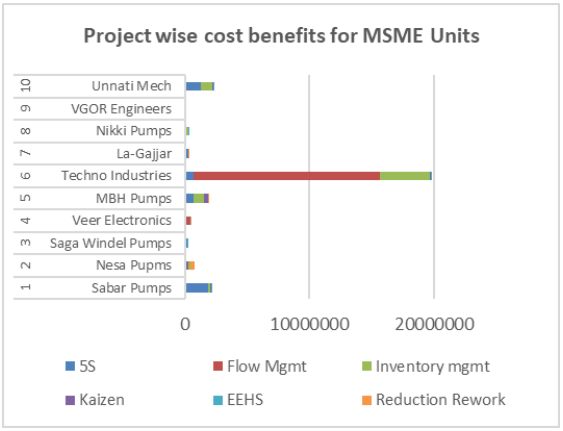

Fig. 4. Project wise cost benefits for MSME Units

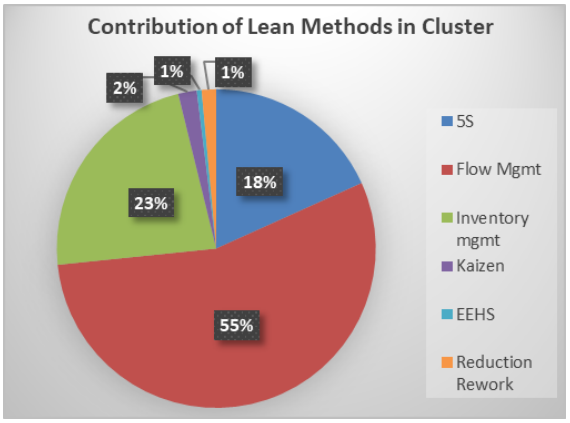

Fig. 5. Contribution of Lean Methods in Cluster

As per the above analysis, the 5 ‘S’, Inventory and Flow Management project has resulted in approx. 95% of the overall cost savings for the clusters.

Hence for any lean methodology, 5 ‘S’, Inventory Management and Flow Management has to be given prime importance to get the desired cost benefits for similar kind of organizations.

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