

Productivity Improvement through Lean, Green and Six Sigma Techniques

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Abstract: *The barriers blocking the effectiveness in lean tools implementation to SME's (Small & Medium Enterprises) in India are found from a case study. For increasing the productivity and efficiency, an integrated form of lean, green and six sigma techniques are suggested. Since SMEs in India form the back bone of economic growth, the productivity and efficiency are to be tuned up for sustained and continual improvement, quality of product is maintained steadily. This can be done by lean-six sigma techniques. A healthy environment has to be maintained hence a green technology is adopted. By an integrated form of lean, green six sigma techniques, products are manufactured at minimum cost, quality is maintained and manufacturing techniques are adopted so as to have minimum environmental damage. Priority is given to the needs and requirement of the customer so as to survive the global competition.*

Keywords: Lean technology, Wastes, Green technology, Environmental Pollution, Six Sigma, SMEs.

1. Introduction

TOWARDS the dawn of twenty first century, as a result of tight global competition, SMEs in India could not sustain a steady increase in productivity and efficiency of its performance. By this time, most of the large scale industries implemented lean tools, six sigma techniques and they have achieved tremendous increase in productivity. But in fact SMEs play a key role in the growth of Indian economy contributing to 45% of industrial output, 40% of exports and 1.3 million jobs per year. So SMEs form the backbone of Indian economy. Most of the SMEs in India started implementing lean tools and complementary tools like TQM, Six Sigma methodologies to improve their performance in early 2005. But in the initial period, these industrial concerns have not shown appreciable growth in their economy and productivity.

At this context we made a thorough study on the effectiveness of implementation of lean tools and related techniques [1]. Our study focused on the following aspects:

- (1) The extent of awareness regarding lean tools, TQM, Six Sigma techniques giving ample stress on maintaining a healthy environment.
- (2) Measures to educate the management executive and workmen regarding Lean tools, Six Sigma techniques, TQM and environment friendly measures.
- (3) Effective implementation of rational integrated version of Lean, Green Six Sigma techniques
- (4) Measurement of performance indicators namely productivity, profit margin, TEEP (Total Effective Equipment Productivity) and OEE (Overall Equipment Efficiency). If performance indicators do not attain the target aimed at, measures are taken to implement the tools effectively. We suggest a six step process for effective implementation.

The different steps are the following:

- a) Identification of the problem or barrier blocking the productivity of performance.
- b) Analyzing the nature of the problem.
- c) Finding out the exact cause of not attaining the required level of increase in productivity.
- d) Remedial measures for rectifying it.
- e) Evaluating the productivity and quality factor attained on implementation of remedial measures.
- f) Ascertain whether required level of increase of productivity has attained by the remedial measures. If not repeat the process until the required level of increase in productivity has attained.

For our study on evolving an effective integrated approach of lean, green and six sigma techniques [2] of attaining manufacturing excellence with continuous process improvement meeting the customer specific requirements. For the work, we have selected an Electronic manufacturing unit. We received liberal support from the management for our study and allowed us to collect data from its record. The company has 770 employees and the manufacturing division of the company has presently 648 workers in two shifts, belonging to four different manufacturing sections namely plating section with 60 workers, molding section with 60 workers, stamping section with 48 workers and assembly section with 480 workers. It has an average turnover of 400 crores with a profit margin of 240 crores. The aim of the company is to become the benchmark in the electronics manufacturing market. The company has received quality performance awards in recognition of achievement of excellent quality and zero customer complaints.

The company record shows that turnover of the company has been steadily increasing until 2005 and as a result of globalization; it has to face a severe competition. To tone up the productivity and efficiency of manufacturing, the company started implementing lean tools. Lean tools were applied to each of the four departments of manufacturing

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namely molding, plating, stamping and assembly section by eliminating the wastes [3]. Manufactured goods have enough diversity and high quality so as to satisfy the needs and requirements of the customer. The lean tools are applied to quality control section so as to reduce the number of quality complaints. Lean tools are applied to supply, purchase and financial sections. To maintain the quality of product in a longer period, six sigma process is implemented.

A six sigma process implies that the industrial unit at most produces 3.4 defective parts per million. A normally distributed process has 3.4 parts per million outside the limits. In six sigma, the process mean shifted by 1.5 sigma. The aim of six sigma is to generate organizational performance improvement, based on customer expectation. So the purpose of a six sigma level is to determine whether a process is improving, deteriorating, stagnant or non competitive.

A related measure taken by the company has been maintaining a healthy environment. Reducing production wastes [4],[5] potentially dangerous raw materials, products or services, pollution is diluted. To maintain a healthy environment, innovative products are recommended, priority for safety of employees, consumers and public.

Our study on the integrated lean, green six sigma technique started in 2013 onwards. The data prior to 2013 is collected from company records and further data is collected by a questionnaire survey designed for the study [13,14]. Questionnaire pertain to check the following abilities of workers

- a) Knowledge about lean tools.
- b) Six sigma practice.
- c) Ability to understand and work as per the quality and process system.
- d) Need of healthy environment.
- e) Experience in the company, its vision and mission etc.

During the study, employees were classified into four groups:

- a) Grade 1 with one to two years of experience forming 20% of the workers.
- b) Grade 2 with two to five years of experience forming 30% of the workers.
- c) Grade 3 with five to eight years of experience forming 25% of the workers.
- d) Grade 4 with above eight years of experience.

From the survey, rating is made in accordance with extent of awareness in LM (Lean Manufacturing) and the workers are classified into four types

- a) Little awareness regarding LM. They are given marks 0.25.
- b) Partial awareness of LM. They are given marks 0.5.
- c) Average awareness. They are given marks 0.75.
- d) Full awareness. They are given marks as 1.

Starting from 2010, study classes and seminars by experts are made for imparting awareness.

2. Lean tools and their implementation

Based on our study and data collected from company records, one can visualize the effect of lean tool implementation on the performance of the company from the estimate of turnover and profit margin of the company and also measure of productivity namely TEEP of the company[13] . It is related to lean awareness. Estimate of year wise lean awareness, profit margin and TEEP is shown below:

Table 1

Year	Lean Awareness (%)	Turnover of the company in crores (Rupees)	Profit margin of the company after tax in crores	TEEP (%)
2011	45	280	110	55
2012	52	284	114	54
2013	59	290	118	56
2014	65	320	151	58
2015	70	364	205	68
2016	75	410	244	72

A graph can be drawn by plotting the turnover of the company along Y axis and lean awareness along X axis. Another graph can be drawn by plotting TEEP along Y axis and lean awareness along X axis.

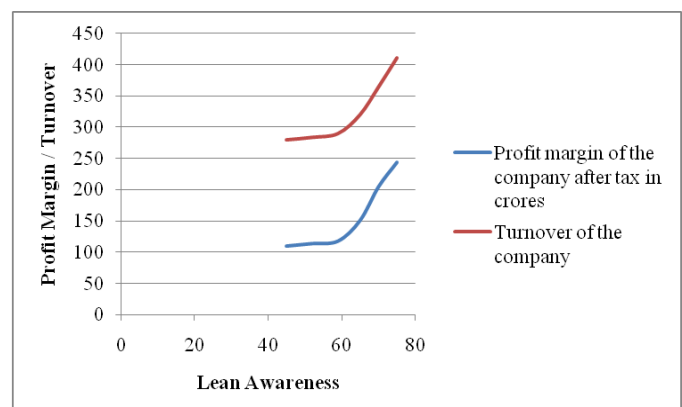


Figure 1: Lean awareness versus turnover of the company

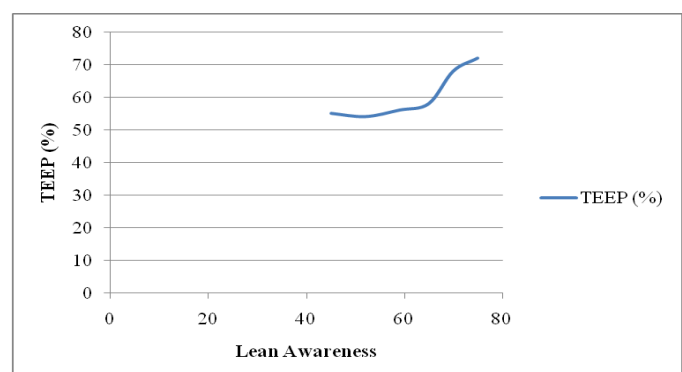


Figure 2: Lean awareness versus TEEP(%)

From the graph it is found that the effectiveness of lean tool implementation increases as lean awareness increases. Our study revealed that effectiveness of lean tool implementation gets tuned up with lean tool awareness among workers [10,11]. But for further improvement in productivity and efficiency of an industry, it is relevant that lean principle [2]

is revised to cope with advanced technologies. In the year 2000, one month's delivery wait could have been tolerated, but today six day or six hour may be too slow and such a wait is intolerable. So lean principle should be revised by the following nine principles:

- (1) Continuous flow: The different departments of manufacturing process are such that each sub process is connected to the next order of process and minimum movement is needed to move its work place from one workstation to next so that there is a continuous flow of products under manufacture.
- (2) Simple lean machines are used to increase efficiency.
- (3) A properly designed lean work cell is essential tool for lean manufacturing.
- (4) During the average work shift, additional parts are required in lean setup, each worker should go about his work with minimum number of interruptions
- (5) The easiness of reconfigurability is necessary for lean workshop.
- (6) Priority is given for the quality of product in other words, products should satisfy the specifications imposed on it and focus is on the ever changing customer requirement.
- (7) Maintainability is a must for lean manufacturing. Products are produced only when customer needs it.
- (8) Another requirement is its accessibility. Using an aluminium framing system, all necessary work components can be mounted in easily accessible location.
- (9) The worker of lean cell must be protected from ergonomic problem or proper work posture of workers.

The revised lean manufacturing techniques in keeping with above nine principles of lean manufacturing resulted in better productivity and efficiency. Six sigma approach is required for continuous process improvement and quality enhancement to increase customer satisfaction [6]. Six sigma approach is customer oriented and aims at achieving considerable monetary gain for definite project. It combines with it a philosophy of management commitment, training and support. Basic purpose of a six sigma strategy is to reduce the variations within tolerance limits of a service performance [7]. For enhancing the productivity and efficiency of their performance, SMEs in India are required to build their knowledge of global products, global quality and technical standards. To increase the quality of the product, continuous enhancement strategy such as six sigma strategy has to be adopted. For that six sigma tools should be adopted and a fair organizational structure is to be set up. It should have a vision and plan statement and should develop project management skill. It has the provision for investment of essential resources, training framework for trainers and mentors, coordination with knowledge management.

Study about the effects of SMEs on environment [8]. Workers are made aware of environment management system, specific environmental law and remediation processes. SMEs have to maintain their operations in such a way as to eliminate environmental damage. To have a rational successful green lean strategy, there should be top management commitment, government initiatives, green sourcing, green design, green operations, green packages,

employee empowerment, commitment and involvement, green innovation and customer awareness.

The following tools like waste segregation reduces reuse, remanufacturing, product recycle, process change and modifications are preferred. The standards to reach green manufacturing include zero safety problems, zero environmental pollution, zero health threat, waste recycling, and waste disposal [9].

The three methods namely lean technology, green technology and six sigma strategy complement each other. Lean tools are essential in the sense that it analyses waste and suggests how to eliminate them. Green techniques study environmental impact and suggest methods to minimize minimal environmental damage. Six sigma techniques aim at quality improvement or a result of continuous process refinement.

3. Conclusion

Thus the integrated form of green, lean strategy with six sigma techniques aims at the reduction of waste and inefficiencies within the process. It stimulates continuous improvement cycles to reach increased process performance rates. Giving emphasis to the needs of the customers and maintaining quality, reducing time delay of supply, reducing cycle time, maintaining an efficient process flow, reducing environmental damage, the productivity and efficiency of the performance of SMEs is highly improved.

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