International Journal of Advance Research in Science and Engineering
Vol. No.4, Special Issue (01), Spetember 2015
www.ijarse.com
IJARSE
ISSN 2319 - 8354

LEAN SIX SIGMA : A REVIEW

Sarita Prasad[1], Sandeep Singhal[2]

[1,2]*Department of Mechanical Engineering, National Institute of Technology, Kurukshetra, (India)*

ABSTRACT

Although many researcher have worked on the implementation of LeanSix Sigma within various organization such as healthcare, technical universities, small and medium organization etc.Lean Manufacturing offers various types of tools & techniques for waste reduction in an organization. Whereas Six Sigmadeals with the measurement of defect rate within organization. Six Sigma is a systematic approach to measure the defect in a system and reduce it to achieve 3.4 defects parts per million opportunities that is a defect free system. In this paper an integrated approach of Lean Manufacturing and Six Sigma is described towards continuous improvement in system. This paper also described the benefits achieved by lean organization through Six Sigma and vice versa.

Keywords: Defects, Lean, Six Sigma.

I. INTRODUCTION

Lean Manufacturing concept has been derived from Toyota Production System (TPS) which is best production system in the world. It is also called as Zero Defect .The Toyota Production System (TPS) provided the basis for Lean Manufacturing approach, described by Womack and Jones (1996). Development of this approach has been started after the Second World War. At that time pioneers of Lean Manufacturing,Eiji Toyoda, TaiichiOhno, and Shingeo Shingo had developed a disciplined, process-focused production system known as "lean production." The aim of this approach was to minimize the consumption of resources that are non-value added processes. Anything that does not contribute a value to a product is known as waste.

Six Sigma began in Motorola Inc in the USA (1996) as a statistically-based method to reduce variation in electronic manufacturing processes. In today's world, Six Sigma is used as an all-encompassing business performance methodology in organizations as diverse as government departments, hospitals, the armed forces, banks, and multi-nationals companies. Six Sigmahas been actually a registered trademark of Motorola Inc., in the USA, who first pioneered Six Sigma methods in the 1980's.

With increasing competition in global markets, the pressure to provide higher quality products and better customer satisfaction has increased. Six Sigma can help organizations learn from and excel at the challenges they meet. It is a statistical methodology, which is used to decide the best approach for a given process. The successful implementation ofSix Sigma results into significant improvements in customer satisfaction and bottom-line benefits. Any manufacturing can view Six Sigma quality as a rigorous application of basic and advanced statistical tools throughout a industry. Six Sigma is a group of statistical components of old Total Quality Management (TQM) programs with the name of "Six Sigma". In other wordSix Sigma as a improved version of TQM. Actually Six Sigmautilized the knowledge of the organization with established statistical tools

to improve both the efficiency and effectiveness of the organization in order to meet customer needs and requirements.

Lean Six Sigma is a methodology which is applied by a team effort to improve performance by removing wastage in process.Lean Six Sigma is a combining effect of Lean Manufacturing and Six Sigma to eliminate the eight kinds of waste which are defects, overproduction, motion, transportation, inventory, extra-processing ,waiting, non-utilized talent.Lean Six Sigma technique is generally used to increase speed ,reduce waste and decrease process complexity. Lean Six Sigmafocuses on the voice of the customer. Lean Six Sigmafocuses on reducing cost through process optimization.Six Sigma is about achievement of customer requirements and stake holder expectations and improving qualityby measuring and eliminating defects.

II. OVERVIEW OF LEAN

There are several quality management concepts that have been developed, the lean concept, as in Lean Manufacturing , lean production, etc. is one of the more wide-spreadand successful concept. lean is basically about utilizing the resources in accordancewith the customers' requirements and to reduce waste. The concept was introduced at a larger scale by Toyota in the 1950s, but notlabeledLean Manufacturing until the now famous book"The Machine That Changed the World", about the automobile appearedin 1990 (Womack et al., 1990).Lean can be defined as a systematic approach for identifying and eliminating waste through continuousimprovement as per requirement of customer[1]

III. TOOLS & TECHNIQUES

3.1. Cellular Manufacturing

In this type of production system plant layout is such that it supports smooth flow of materials and components with minimum transport, motion and waiting time. Cellular manufacturing aim to move products through the manufacturing process one piece at a time a rate determined by customer demand (pull).

3.2. 5s

5S includes *Sort, Set in Order, Shine, Standardize and Sustain* is a system to reduce waste and optimize productivity through maintaining an orderly workplace.

3.3. Value Stream Mapping

A value stream is all the actions (both value added and non-value added) currently required to bring a product through the main flows essential to every product:

(1) The production flow from raw material into the arms of the customer.

(2) The design flow from concept to launch.

3.4. Just- In-Time Production System/ KANBAN

As we all know JIT is the pillar of TPS and so it is also the pillar of Lean Production System. JIT enables a company to produce what exactly customer wants, in what amount and when he wants. JIT means supplying right products in right amount at right time and at right place. It aims at zero inventory, zero lead time and zero defects in the system.

3.5. Kaizen (Continuous Improvement)

It is a strategy where employees work together proactively to achieve regular, incremental improvements in the manufacturing process. It combines the collective talents of a company to create an engine for continually eliminating waste from manufacturing processes.

3.6 Muda (Waste)

Anything in the manufacturing process that does not add value from the customer's perspective is called as Muda. Eliminating muda (waste) is the primary focus of Lean Manufacturing .

3.7 Total Productive Maintenance (TPM)

TPM is a holistic approach of maintenance that focuses on proactive and preventative maintenance to maximize the operational time of equipment.

3.8. Poka Yoke (Error Proofing)

Design error detection and prevention into production processes with the goal of achieving zero defects. It is difficult (and expensive) to find all defects through inspection, and correcting defects typically gets significantly more expensive at each stage of production.

Some of the researchers have given their opinions about Lean Manufacturing which are described below.

Bon and SiokKee (2015) have used two type of lean assessment tools, value stream mapping and gap analysis. They were applied to assess the current manufacturing system of the selected company for the purpose to enable to present a positive lean measurement of selected company to support the identified objectives [2].

Elmoselhy (2013) has developed four technical pillars Flexible focused factory, globalized fractal E-manufacturing, innovative value chain strategies, and designing dynamic manufacturing strategies of the proposed hybrid lean–agile manufacturing system technical facet. The study shows that hybridizing the lean and agile systems together is technically valid and can be implemented in an industrial setting[3].

Behrouziand Wong (2011) have measured the lean performance by using fuzzy membership functions. Based on simple no. (output of performance) manager & decision makers can easily analyze the effectiveness of their manufacturing strategies and identify the potential opportunities for improvement[4].

Parveen et al. (2011) has given the paper with the objective to explore the capabilities of lean supply chain in green technology & environmental performance. Investigation of the environmental performance of lean supply chain is done with environmental waste reduction as the key performance indicator[5].

Mo (2009) has given three showcase projects demonstrating how return on investment can be achieved with the application of advanced manufacturing technologies. Instead of committing large capital expenditure in IT based manufacturing systems, the showcases started by applying Lean Manufacturing principles and transformed the business practices to adopting latest IT systems for the planning and control of manufacturing[6].

Aulakh and Gill (2008) described the importance of 5 element of lean is discussed to appreciate the synergetic effect of each element on other, towards making an organization lean. They found a result that it is very important for top management and all other to understand lean thinking & lean principles[7].

IV. OVERVIEW OF SIX SIGMA

Six Sigma has been started with Motorola,Mikel Harry began to influence the organization by studying the variations in processes as a way to improve them. These variations are known in statistics as standard deviations and are represented by the Greek letter sigma (σ). Sigma capability measures the capacity of a process to develop without defects. A defect means an unsatisfied customer. The quality scale of Six Sigma measures the number of sigmas between the interval defined by the specification limits. The greater the number of sigmas between the specification limits the smaller will be the value of Sigma and the lower the number of defects.

Six Sigma uses two different sets of methodologies, DMAIC and DMADV. The DMAIC and the DMADV methodologies have aimed to view different sectors of a business simultaneously but address them separately. The methodologies overlap during the examination process and but achieve the same end goal that is improvement of business processes.

Each methodology has its own set of guidelines and goals targeted at improving business processes through the use of data collection and statistical tools. Both methodologies are designed to achieve the same goal, but they have very slight difference while implementing in process. The Design for Six Sigma process is known as DMADV - Define, Measure, Analyze, Design and Verify. This process is generally used for product design before manufacturing. The DMAIC process is used to design the manufacturing process through reduction of common cause variation. The DMADV process is designed to remove variation between what the customer wants and what actually was designed. The DMADV methodology should be implemented when a service or product needs to be developed in a company where does not already exist or it does not reach the specific sigma level.

4.1 DMAIC

The set of Six Sigma methodologies that is most applicable to the manufacturing or production side of a product or service, DMAIC includes these project stages:

Define -Identification of specific processes to be examined

Measure – Record the data and use metrics to track effectiveness and evaluate efficiencies

Analyze – Critical analyzing and reviewing the data and clarify goals

Improve - Create changes in business processes geared toward improvement and better reach closer to corporate goals

Control - Build a system of checks and adjustments for ongoing improvement in production processes

4.2 DMADV

The complementary set of Six Sigma processes that is most applicable to examining and improving the customer relations side of a company, DMADV includes these project stages:

Define - Define customer needs in relation to a product or service.

Measure –Involves the use of electronic data collection to measure customer needs, response to product, or review of services

Analyze – Utilize metrics to evaluate areas where product or service can be better aligned to customer goals and needs

Design - overlap the improvement of business processes that streamline corporate goals to best meet client and customer needs

Verify - Build a system of tests and models to check that customer specifications are being met through on-going improvements.

The fundamental objective of the Six Sigma methodology is the implementation of a measurement strategy that focuses on process improvement and variation reduction through the application of the DMAIC process or DMADV process.

Some of the researchers have given their opinions about Six Sigma which are described below.

Abdolshah et al (2009) have specified the key performance indicators of Six Sigma and elements to cover a wider range of services. They have identified the main challenges in application of Six Sigma in service industries by comparing the features of services and manufacturing industries. They proposed that for successful implementation of Six Sigma in service industry a design phase should be added to DMAIC that is DDMAIC[8].

Schroeder et al (2008) have proposed a rigorous base definition of Six Sigma from the literature & field study that can be used for further research. They have provided an underlying theory for Six Sigma. It includes the concept of ambidextrous organization, parallel meso organization ,structural control and structural exploration. They have differentiated Six Sigma from Total Quality Management & other quality management approaches in order to indicate the new about this approach[9].

Raisinghani et al (2005) have described that the immediate goal of Six Sigma is reduction of defects. Reduction of defects lead to yield improvement, higher yields, improves customer satisfaction. Defect reduction also lead to cost reduction. Lean Six Sigma is process focus and aims to highlights process improvement opportunities through systematic measurement[10].

Wessel and Burcher (2004) have attempted to describe the power of Six Sigma in the service industry through a disciplined approach to improving product, process or service quality. This paper briefly presents the possible areas when Six Sigma could be exploited in service function[11].

Linderman et al (2003) have presented a paper that develops an understanding ofSix Sigma phenomenon from a goal theoretic perspective . This paper helps to serve as a foundation for developing knowledge about Six Sigma[12].

Antony and Banuelas (2002) have described the key ingredients, which are essential for Six Sigma implementation. These key ingredients are management commitment and involvement, understanding of Six Sigmamethodology , techniques, linking Six Sigma to business strategy and with customer, project selection, reviews & tracking, organizational infrastructure, cultural change, project management skills, linking Six Sigma to supplier, training & link of Six Sigma with employees[13].

V. OVERVIEW OF LEAN SIX SIGMA

The term lean Six Sigma is used to describe the integration of lean and Six Sigma philosophies. The concept of lean Six Sigma is an approach to process improvement. It can be said that in practice the majority of efforts to fully and comprehensively implement a lean Six Sigma initiative to its full potential have not been realized. This failure tosustain a change towards continuous improvement can be attributed for one, to the lack of commitment

from management . Lean tools and principles can be integrates into Six Sigma in an organization.Nowadays organizations that use Six Sigma are making an effort to integrate Lean into their existing process. Six Sigma focuses on process quality whereas Lean focuses on waste reduction. To obtain this advantage, manufacturer must cross a difficult obstacle: integrating Lean without creating obstacles in the existing Six Sigma structure. If the Lean introduction is not done properly, it results in more pitfalls than successes. If an organization already hasSix Sigma then the integration of lean can be achieved through five lean tools.

5.1 Value Stream Mapping

In the Analyze phase of a DMAIC methodology, a value stream map can be created that shows the flow of materials and information, and categorizes activities into three segments: value enabling, value adding and non value adding(waste). VSM tool is used to identifying and eliminating the non-value added activities in each process and reducing the wait time. Value enabling activities cannot be totally eliminated from a system. However they can be sub categorized into value adding and non-value adding activities, allowing those value enabling activities that are non-valued added to be eliminated. These eliminations help make a process more compact – a benefit in process improvement projects aimed at reducing variation. This tool also can be a part of a Kaizen cycle, incorporated within the Analyze and Improve phases.

5.2 Takt Time

Takt is a German word that can be roughly called as "beat." Takt time is the rate at which a completed project needs to be finished in order to meet customer demand.

Mathematically,

takt time = *Available time for production / required units of production*

5.3 Ishikawa (Cause-and-Effect) Diagram

In the Analyze phase, the absence of statistical data sometimes can make the identification of a root cause difficult. In this time a cause-and-effect diagram, can make the task more manageable.

5.4 Heijunka (Load Balancing)

A Japanese term, *Heijunka* refers to a system of production designed to provide a more even and consistent flow of work. This principle can be implemented in the Design phase if the root cause analysis has been done during Analyze phase and bottlenecks are found in the process. Load balancing is used to introduce a pull in the system rather than letting it operate on push – thus eliminating the bottlenecks. Introducing a level load balance in the system also automatically reduce inventory. If Takt time principles are used while designing the system, it would help ensure a level load balance.

5.5 Poka-Yoke (Mistake Proofing)

A Japanese phrase Poka yoke have meaning mistake proofing, *poka-yoke* can be used when designing a new system altogether with DMADV (Define, Measure, Analyze, Design, Verify) Six Sigma methodology. A combination of an Ishikawa chart and Pareto analysis can be useful in Analyze phase and to be listing the major issues in process. During the Improve and Design phases, the possibilities for eliminating a major cause of errors can be achieved by improving or redesigning the system to avoid error-inducing scenarios.

Researchers have implemented Lean Six Sigma in different scenarios which are described below.

Tenali et al (2015) have used the lean Six Sigma methodology in a technical institute for improving the admission to placement ratio by considering all the necessary factors along with psychological dimension of students. The implementation of this tool results into drastic change of sigma value through increasing the admission of institute[14].

Kanakana et al (2010) said that Lean Six Sigma is generally applied to manufacturing sector & service sector also. In this paper researchers is try to use this process control strategy of lean Six Sigma implement it in a academic education. Through successful implementation of lean Six Sigma they improved the through put rate & increases faculty revenue[15].

Delgado et al(2010) have described the benefits and difficulties felt by an organization after implementing Lean Six Sigma. GE Money Portugal namely organization has introduced the lean component in their established Six Sigma corporate culture. They have achieved an increase of productivity by the application of lean and finds the improvement in their processes. They have improved revenue by increasing customer satisfaction & by servicing more customer, due to focusing on projects such as decreasing operational cost by improving efficiency[16].

Koning et al (2006) basically outlines a methodology & presents examples to illustrate how principles of lean thinking and Six Sigma can be combined to provide an effective framework for producing systematic innovative effort in healthcare. The benefits achieved through this approach is improving quality, providing better healthcare etc[17].

Dahlgaard& Park (2006) mainly focused to analyze the principles & results of lean production & comparing result of lean production philosophy with Six Sigma quality process and principles of total quality management[18].

VI. DIFFERENCE BETWEEN LEAN AND SIX SIGMA

Lean Six Sigma is a combined approach of lean and Six Sigma. But both the philosophy have differences in terms of origin, process, methodology, tools, effects in process after implementation. Some of the differences are given below in the TABLE 1.

TABLE 1 – Difference between Lean and Six Sigma

S.NO.	CONCEPT	SIX SIGMA	LEAN
1.	Origin	Japan (Motorola)	Japan(Toyota)
2.	Theory	Based on zero defects	Based on removal of waste
4.	Methodology	DMAIC or DMADV	Understand customer requirement and after that use lean tools & Techniques
5.	Primary effect	Save money	Reduced lead time
6.	Secondary effect	Achievement of business goals and improve performance	Improve productivity and customer satisfaction

VII. CONCLUSION

Lean Six Sigma can be applied to any process for improvement such as healthcare, university, financial service etc. Lean Six Sigmabasically first identifies the non value adding processand areas of improvement to ensure high quality of production. The aim of Lean Six Sigmais to improve throughput rate, where by providingtools for managers to manage andcontrol the process. The organization should measure the process properly. The result found after the implementation of lean Six Sigma is that theprocess will be in control insuch a manner that defects areprevented and if they do occur, the cause is immediatelydetected to avoid future defects.

REFERENCES

[1]. Andersson, Eriksson and Torstensson, Similarities and differences between TQM, six sigma and lean, The TQM Magazine, Vol. 18 Iss 3 pp. 282 - 296(2006)

[2]. Bon and Kee,Implementation of Lean Manufacturing for Productivity Improvement in Malaysia, Proceedings of the 2015 International Conference on Industrial Engineering and Operations Management Dubai, United Arab Emirates (UAE) (2015)

[3]. Elmoselhy, Hybrid lean–agile manufacturing system technical facet, in automotive sector Journal of Manufacturing Systems 32 (2013) 598– 619 (2013)

[4]. Behrouzi and Wong, Lean performance evaluation of manufacturing system : A dynamic and innovative approach, Published by Elsevier Ltd.Procedia Computer Science 3 (2010)

[5]. Parveen et al, Integration Of Lean And Green Supply Chain - Impact On Manufacturing Firms In Improving Environmental Efficiencies, Proceedings of the IEEE ICQR (2011)

[6]. Mo ,The role of lean in the application of information technology to manufacturing, Journal of Computer in Industry 60 (2009) 266–276 (2009)

[7]. Aulakh and Gill, Lean Manufacturing- a Practitioner's Perspective, Proceedings of the 2008 IEEE IEEM (2008)

[8] Abdolshah et al, Overcoming the challenges of implementating Six Sigma in service industries, International Conference on Information Management and Engineering, IEEE (2009)

[9] Schroeder et al, Six Sigma: Definition and underlying theory, Journal of Operations Management 26 (2008) 536–554

[10] Raisinghaniet al, Six Sigma:concepts, tools, and applications, Industrial Management & Data Systems, Vol. 105 Iss 4 pp. 491 – 505 (2005)

[11] Wessel and Burcher, Six sigma for small and medium-sized enterprises, The TQM Magazine, Vol. 16 Iss 4 pp. 264 – 272 (2004)

[12] Linderman et al, Six Sigma: a goal-theoretic perspective, Journal of Operations Management 21 193–203 (2003)

[13] Antony and Banuelas, Key ingredients for the effective implementation of Six Sigma program, Measuring Business Excellence, Vol. 6 Iss 4 pp. 20 – 27 (2002)

[14] Tenaliet al, Implementing lean six sigma to improve the ratio of admissions to placements in an academic year: statistical and psychological case study of a technical institute, Proceedings of the 2015

International Conference on Industrial Engineering and Operations ManagementDubai, UAE, March 3 - 5, 2015

[15] Kanakana et al, Lean Six Sigma Framework to Improve Throughput rate, , Proceedings of the 2008 IEEE (2010)

[16] Delgado et al, The implementation of lean Six Sigma in financial services organizations, Journal of Manufacturing Technology Management, Vol. 21 Iss 4 pp. 512 – 523 (2010)

[17] Koning et al, Lean Six Sigma in Healthcare, Journal for Healthcare Quality Vol. 28, No. 2, pp. 4–11 (2006) National Associationfor Healthcare Quality

[18] Dahlgaard and Park, Lean production, six sigma quality, TQM and companyculture, The TQM Magazine, Vol. 18 Iss 3 pp. 263 – 281 (2006)