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A REVIEW PAPER ON WORK STUDY, LEAN MANUFACTURING AND SIX SIGMA

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Abstract

Industrial Engineers bring people, resources, equipment, and technologies together to improve system and processes. Industrial engineers have developed numerous new tools and techniques to improve both system and processes, especially in the last decade or two. Still different lean tools and conventional IE techniques such as time study, method study etc. have not lost its success rate. Lean and Six Sigma are two widely acknowledged business process improvement strategies available to organisations today for achieving dramatic results in cost, quality and time by focusing on process performance. Lean tools and techniques generates savings to the bottom line of organization. Lean manufacturing is concerned with the development, improvement, and the implementation of integrated systems of men, machines, money, knowledge, information, energy, materials, analysis as well as the mathematical, physical and operational model together with the principles and methods of engineering design to identify, predict, and evaluate the result to be obtained from such process and further improve the processes.

KEYWORDS: Work Study, Lean Manufacturing, Six Sigma, Quality and Productivity Improvement

INTRODUCTION

The last two decades has witnessed an increased pressure from customers and competitors for greater value from their purchase whether based on quality, faster delivery, or lower cost (or combination of both) in both manufacturing and service sector (*Basu 2001*, *George 2002*). This has encouraged many industries to adopt either Six Sigma (as their process improvement and problem solving approach) or Lean Manufacturing (for improving speed to respond to customer needs and overall cost) as part of management strategy to increase the market share and maximise profit. *See M. Kumar et. al. (2006)*
The definitions and description of various quality management tool are as follows:
Method Study: - Method study is the process of subjecting work to systematic, critical scrutiny to make it more effective and/or more efficient. It is one of the keys to achieving productivity improvement. It was originally designed for the analysis and improvement of repetitive manual work but it can be used for all types of activity at all levels of an organisation.
Time Study: - A time study can establish a baseline from which to drive improvement efforts, or set a standard to control performance. Without basic time study measures, it is impossible to know whether work has improved or whether there are differences in performance in a unit.
NIST (2000) defines lean *as a systematic approach to identifying and eliminating waste through continuous improvement, flowing the product at the pull of the customer in pursuit of perfection.*
Six sigma, is defined *as a business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction by some of its proponents, see Magnussonet al. (2003*).
All the tools and techniques differ from each other but the overall goal is to improve and optimize the resources namely men, machine, money, knowledge, information, energy, materials, etc. Method study is basically conducted to simplify the work or working methods and must go towards higher productivity. It is always desirable to perform the requisite function with desired goal minimum consumption of resources. Method signifies how a work is to be done i.e. description of how we consume resources in order to achieve our target? Methods can determine the amount of input materials, time power and money consumed. So methods may be considered the core where one can attempt to reduce the consumption of resources thereby reducing cost per unit output through utilization of proper methods. The method design can decided the cost and quality of output produced. Method for establishing employee productivity standards in which a complex task is broken into small, simple steps, the sequence of movements taken by the employee in performing those steps is carefully observed to detect and eliminate redundant or wasteful motion, and precise time taken for each correct movement is measured. From these measurements production and delivery times and prices can be computed and incentive schemes can be devised. Generally appropriate only for repetitive tasks, time and motion studies were pioneered by the US industrial engineer Frederick Winslow Taylor (1856-1915) and developed by the husband and wife team of Frank Gilbreth (1868-1924) and Dr. Lillian Gilbreth (1878-1972). The core idea of lean manufacturing is actually quite simple…relentlessly work on eliminating waste from the manufacturing process. Waste is defined as any activity that does not add value from the customer's perspective. According to research conducted by the Lean Enterprise Research Centre (LERC), fully 60% of production

activities in a typical manufacturing operation are waste – they add no value at all for the customer. Company has a tremendous opportunity to improve, using lean manufacturing techniques and other manufacturing best practices. Techniques that enable you to deliver higher quality products at significantly lower costs. It can be difficult to find reliable and well-written information about improvement techniques for manufacturing. So, the goal is to provide with the absolute best source of easy-to-understand information for helping you improve the efficiency, effectiveness, and profitability of your manufacturing operations. *(https://www.**isixsigma**.com/)*The concept of Lean Manufacturing is derived from the methods developed at shop floor of Toyota, which are described in detail by the authors like Taiichi Ohno and Shiego Shingo.Some of the lean tools are 5S, Kanban, Total Productive Maintenance (TPM), Jidoka, Process Mapping (Value Stream Mapping), Kaizen, SMED (Single Minute Exchange of Die), Single Piece Flow, etc.Six Sigma has developed as one of the most effective business improvement strategies over the years. This quantitative approach aims at improving efficiency and effectiveness of the organization. It is the methodology having statistical base focusing on removing causes of variations or defects in the product or core business processes. The improvement focus is on business outputs which are of critical importance to the customers. In the current dynamic industrial scenario, quality alone is not the winning criteria; consistent supply of quality goods as per the committed delivery schedules makes the customers happy. Six Sigma `methodologies addresses the major root causes and guarantees the targeted results, both in terms of improvements desired and time span fixed. It is a disciplined, data-driven approach and methodology for eliminating defects in any process – from manufacturing to transactional, from products to services. This breakthrough improvement strategy delivers results of productivity, profitability and quality improvements based omits highly effective approach (Desai, 2008).

APPLICATION STEPS

METHOD STUDY

The process is often seen as a linear, described by its main steps of:

- Select (the work to be studied);
- Record (all relevant information about that work);
- Examine (the recorded information);
- Develop (an improved way of doing things);
- Install (the new method as standard practice);
- Maintain (the new standard proactive).

The cyclic process often starts with a quick, rough pass in which preliminary data are collected and examined before subsequent passes provide and handle more comprehensive and more detailed data to obtain and analyse a more complete picture.

TIME STUDY

When practitioners conduct a time study, it is essential that they know what they want to study. Work is not strictly a set of disconnected tasks, it is a process. These processes have names, such as maintenance or transfers, and begin with inputs, move on to processes in which inputs are modified, and conclude with outputs.While engaged in these input, process, output (IPO) chains, other things may intrude: mulling things over, asking a question, taking a phone call, going to lunch and so on. In addition, people have different work styles – some are fast and diligent; others take their time. There are many opportunities for variation in conducting a task. The result: Time measurements are not precise, but estimates of how long a task takes. Over time, or by measuring the work of several people, it is possible to come to a general understanding of how long the work takes, which is good enough to get started.

LEAN MANUFACTURING

Lean manufacturing is being utilized by businesses of all sizes today. Although it took a few years to become mainstream, the success stories from mid-size to large corporations have pushed lean manufacturing down to very small organizations.

However, a road map can be used with common sense. Lean manufacturing has been called "common-sense manufacturing", although not always "common practice". Here are 20 steps that comprise a lean manufacturing road map *(https://www.**isixsigma**.com/)*:

1. Form team (mix of lean manufacturing and relevant business experience)
2. Develop communication and feedback channel for everyone
3. Meet with everyone and explain the initiative
4. Begin to train all employees (lean overview, eight wastes, standard operations, kaizen, RCPS, PDCA)
5. Facility analysis – Determine the gap between current state and a state of "lean"
6. 5-S - It is the foundation of lean. Workplace organization is critical for any lean initiative
7. TPM – Begin Total Productive Maintenance early (used throughout lean)
8. Value Stream Mapping – Determine the waste across the entire system
9. 7 (or 8) waste identification – Use with value stream mapping to identify system waste
10. Process mapping – A more detailed map of each process
11. Takt time – Determine need to produce on all processes, equipment
12. Overall equipment effectiveness and six losses – Determine the losses on all processes and equipment
13. Line balance – Use, if necessary, with takt time and OEE
14. SMED – Push setup times down to reduce cycle time, batch quantity and lower costs
15. Pull/one-piece flow/Continuous Flow Analysis – Utilize kanban and supermarkets
16. Analyze quality at the source application – Poor quality stopped at the source
17. Implement error-proofing ideas

18. Cellular manufacturing/layout and flow improvement – Analyze facility and each process
19. Develop standardized operations – Concurrently with SMED, line balance, flow, layouts
20. Kaizen – Continue improving operations, giving priority to bottlenecks within the system.

SIX SIGMA

Six Sigma is a systematic, data driven approach using the Define, Measure, Analysis, Improve and Control (DMAIC) process and utilization design for Six Sigma method (DFSS). Steps for implementing six sigma through DMAIC:

- Define: The main objective of this stage is to outline the borders of the project. Stakeholders agree on the parameters that will define the project Scope and budgetary items, as well as customer needs, are aligned with project goals Team development takes place as the project begins to take shape.
- Measure: The main objective is to collect data pertinent to the scope of the project. Leaders collect reliable baseline data to compare against future results Teams create a detailed map of all interrelated business processes to elucidate areas of possible performance enhancement.
- Analyse: The main objective is to reveal the root cause of business inefficiencies. Analysis of data reveals areas where the implementation of change can provide the most effective results Groups discuss ways that the data underscores areas ripe for improvement
- Improve: The main objective at the end of this stage is to complete a test run of a change that is to be widely implemented. Teams and stakeholders devise methods to address the process deficiencies uncovered during the data analysis process Groups finalize and test a change that is aimed at mitigating the ineffective process Improvements are ongoing and include feedback analysis and stakeholder participation
- Control: The objective of the last stage of the methodology is to develop metrics that help leaders monitor and document continued success. Six Sigma strategies are adaptive and on-going. Adjustments can be made and new changes may be implemented as a result of the completion of this first cycle of the process. At the end of the cycle, additional processes are either addressed or the initial project is completed.

BENEFITS AND ADVANTAGES

METHOD STUDY

- Prime objective is to simplify the job by developing more effective and economical always of doing it.
- Supporting objectives (How to achieve prime objective)…
- Better utilization of manpower and other resources
- Elimination of unnecessary work
- Reduction in unnecessary fatigue
- Identify bottleneck and try to minimize it
- Bring standardization in operation
- Improve… design, Process, Layouts and methods of Material Handling, Working conditions, Safety standards, etc.

TIME STUDY

- Prime objective is to eliminate ineffective time and establish standards for the work (Setting standards times).
- Supporting objectives
- Compare number of alternatives methods.
- Determine no. of machines a worker can handle.
- Distribute work to a group of operator.
- Basis for estimation made for tenders, machine loading, delivery schedules etc.
- Basis for setting standards for machine utilization and labour performance.
- Basis for incentive scheme.

LEAN MANUFACTURING

- Quality performance, fewer defects and rework (in house and at customer).
- Fewer Machine and Process Breakdowns.
- Lower levels of Inventory.
- Greater levels of Stock Turnover.
- Less Space Required.
- Higher efficiencies, more output per man hour.
- Improved delivery performance.
- Faster Development.
- Greater Customer Satisfaction.
- Improved employee morale and involvement.
- Improved Supplier Relations.
- Increase Profits
- Increased Business.

SIX SIGMA

The main advantage of Six Sigma compared to other approaches to quality control is that Six Sigma is customer driven. Six Sigma is defined as a limit of 3.4 defects per one million products or service processes, where anything not acceptable to the end customer is considered a defect. Six Sigma addresses the entire process behind the production of an item or completion of a service, rather than just the final outcome. It is proactive rather than reactive, as it sets out to determine how improvements can be made even before defects or shortcomings are found. Even businesses that are unable to implement Six Sigma due to cost or practicality may benefit from having a partner or employee learn and implement some of the basics of the system, especially the philosophy of proactivity and customer satisfaction that underlies Six Sigma. It is particularly valuable to a specialty manufacturing concern that produces precision goods, such as medical technology, where quality is the utmost customer priority and the customer expects to bear the cost of the Six Sigma process.

BARRIERS & LIMITATIONS

METHOD STUDY

- Each worker under study may have different working style, fatigue level, etc.
- Method of each work is to be regularly studied and modified based on modern tools and techniques.
- Method study requires very minute observations and recordings are to be analysed again and again to get better results.
- Training is required for method study.

TIME STUDY

- Standards cannot be established by this technique on jobs which are not well defined.
- In situations where it is difficult to define quality precisely standards and production incentives may cause deterioration in quality levels.
- It is not possible to maintain standards where piece rate system of wage payment exists.
- Labour unions may oppose the application of time study where they are strong.
- Time study is applicable only where the work is visible. So it can be applied only in manual job and for thinking portions of the job.
- Only specific type of jobs which have identifiable starting and ending points can be timed accurately.

LEAN MANUFACTURING

- Implementing lean principles in your workplace requires input and participation from your production staff.
- Lean techniques can be overused. When tracking of productivity and waste starts to impact the time used for production, the solution becomes the problem
- When lean principles are first applied, you can expect larger returns than later down the road. It is tempting to push those expectations, but you must examine the value of improvements.
- When a certain level of refinement is met, using lean methods to squeeze more economy from production can discourage workers, reversing positive motivation and undermining your leadership.
- Trends of backsliding in previous improvements may indicate worker resentment. Striking a balance between stasis and continuous improvement is a challenge in any lean environment.

SIX SIGMA

Six Sigma is applied to all aspects of the production and planning process, it may create rigidity and bureaucracy that can create delays and stifle creativity. In addition, its customer focus may be taken to extremes, where internal quality-control measures that make sense for a company are not taken because of the overlying goal of achieving the Six Sigma-stipulated level of consumer satisfaction. Six Sigma is extremely costly for many small businesses to implement. Employees must obtain training from certified Six Sigma institutes in order for an enterprise to receive Six Sigma certification. Even if a firm wishes to implement Six Sigma without formal certification, much training is necessary in order to understand the system and how to apply it to particular business processes.

GENERAL OVERVIEW OF CASE INDUSTRIES

The following table shows some of the practical and industrial case studies carried out in the above mentioned fields:

Table 1: Overview of Case Studies referred

TITTLE	JOURNAL/ CONFERENCE YEAR	AUTHOR(S)	FIELD AREA/ PRODUCT/ DESCRIPTION	PURPOSE
Implementing the Lean Sigma framework in an Indian SME: a case study	Production Planning & Control (2006)	M. Kumar , J. Antony, R. K. Singh, M. K. Tiwari & D. Perry	Die Casting Industries (automobile accessories)	Reduce defects in automobile accessories
Sensitisation of SMEs towards the implementation of Lean Six Sigma – an initialisation in a cylinder frames manufacturing Indian SME	Production Planning & Control (2012)	S. Michael Gnanaraj, S.R. Devadasan, R. Murugesh, C.G. Sreenivasa	Evolving Deficiencies Overcoming Lean Anchorage Define Measure Analyse Improve Control Stabilize for cylinder frames	Increase productivity reducing defects in cylinder frames

Implementing lean sigma framework in an Indian automotive valves manufacturing organisation: a case study	Production Planning & Control (2011)	S. Vinodh, S.G. Gautham, Anesh Ramiya R.	Automotive valve manufacturing organisation	To introduce systematic and scientific management in the system
Reducing Welding Defects in Turnaround Projects: A Lean Six Sigma Case Study	Quality Engineering (2014)	Nicole C. Anderson, Jamison V. Kovach	Welding Defects in construction company	Increase productivity thus improving project performance
A Lean Six-Sigma approach to touch panel quality improvement	Production Planning & Control (2009)	MingNan Chen & Jr Jung Lyu	Touch Panel Manufacturing Industries	To reduce process variability and increase quality in business processes
Implementing lean sigma in an Indian rotary switches manufacturing organisation	Production Planning & Control (2014)	S. Vinodh, S. Vasanth Kumar & K.E.K Vimal	Rotary switches Manufacturing	To reduce waste and enhance bottom-line results to win customer loyalty
Curbing variations in packaging process through Six Sigma way in a large-scale food-processing industry	Journal of Industrial Engineering International (2014)	Darshak A. Desai, Parth Kotadiya, Nikheel Makwana, Sonalinkumar Patel	Milk products making industry (AMUL)	Reducing variations in packaging
Productivity improvement through Lean Development & Work Study methods	International Journal of Research in Engineering and Technology(2014)	Prathamesh P. Kulkarni, Sagar S. Kshire, Kailas V. Chandratre	Set Up Time Reduction and application of 5S	Increase productivity by decreasing setup time (SMED).
Review on Improvement of Workflow and Productivity through application of Time and Motion Study Technique	International Journal for Scientific Research & Developmen (2014)	Ankit Vekariya, Ashutosh Kumar	General Techniques of Time and Method Study	Smoothening work flow using Time and Motion study
An Effort to apply Work and Time Study Techniques in a Manufacturing units for enhancing Productivity	International Journal of Innovative Research in Science, Engineering and Technology (2013)	Patange Vidyut Chandra	Systematic application of Method study & Time study	Increasing productivity, decreasing fatigue level using Time and Motion study
To Improve Productivity by Using Work Study & Design a Fixture In Small Scale Industry	IJTARME (2012)	Mayank Dev Singh	Basic Work Study Method to Reduce Time for making product	Reduction of cycle time
The Use of Work Study Techniques in Optimizing Manufacturing Plant Maintenance Processes: an Investigation into a Fertilizer Manufacturing Company in Zimbabwe	International Journal of Science and Research (2013)	Mutombo Zana Tapiwa, Mugwindii Kumbirayi, Chikuku Tauyanase	Reduction in Fluctuations in availability & Productivity of the fertilizers	Reducing maintenance issues
Application of Six Sigma at an export oriented unit: a case study	Int. J. Productivity and Quality Management (2016)	Nayankumar J. Prajapati, Darshak A. Desai	Six Sigma Application for Export Oriented Units	To reduce variation in an aircraft manufacturing unit

Improving productivity and profitability through Six Sigma: experience of a small-scale jobbing industry	Int. J. Productivity and Quality Management (2008)	Darshak A. Desai	Reduction in Rejection of Sleeves using Six Sigma Methodology	Application of six sigma in small scale jobbing industry
On some aspects of developing an effective model for the implementation of Six Sigma concept in small and medium sized manufacturing enterprises in India	International Journal of Management Science and Engineering Management (2011)	N. L. Hiregoudar & Bhimasen Soragaon	Six Sigma process improvement strategy for SMEs	To reduce the manufacturing cost by reducing percentage of defective products and improve product quality by an appropriate training to employees
Six Sigma implementation framework for SMEs – a roadmap to manage and sustain the change	International Journal of Production Research (2011)	Maneesh Kumar , Jiju Antony & M.K. Tiwari	Developed a road map for implementation Six Sigma for Small Scale Industries	Guidance for application of six sigma in small scale industries
Assessing the status of six sigma implementation in the Indian industry	Emerald (2009)	Jiju Antony, Darshak A. Desai	Survey on Implementation of Six Sigma Methodology in India	Level of Six Sigma application in India
Quality and productivity improvement through Six Sigma in foundry industry	Int. J. Productivity and Quality Management (2012)	Darshak A. Desai	Small scale industries in India	Application of Six Sigma in India
Patient Discharge Time Improvement by Using the Six Sigma Approach: A Case Study	Quality Engineering (2013)	Mahmoud El-Banna	Application of Six Sigma in Hospitals	Reducing discharge time for Patients
Improving the Hospital Discharge Process with Six Sigma Methods	Quality Engineering (2009)	Theodore T. Allen , Shih-Hsien Tseng , Kerry Swanson & Mary Ann McClay	Application of Six Sigma in Hospitals	Reducing discharge time for patients using statistical methods
Improving customer delivery commitments the Six Sigma way: case study of an Indian small scale industry	Int. J. Six Sigma and Competitive Advantage (2006)	Darshak A. Desai	Challenges and advantages of the Indian SSI sector, Sanitary Stainless Steel Valves and Fittings	To determine success factor of Six Sigma methodology in Indian SSI sector through a case study
Improving the efficiency of IT help-desk service by Six Sigma management methodology (DMAIC) – a case study of C company	Production Planning & Control: The Management of Operations (2011)	Shing-Han Li , Chi-Chuan Wu, David C. Yen & Ming-Chih Lee	Information Technology (IT) help desk services	To improve service quality and efficiency
Innovation quality management in public sector research and development organizations: Application of six sigma methodology	International Journal of Management Science and Engineering Management (2011)	Avtar Singh Rana , Santosh Kumar Nanda & Bharat Shankar Sontakki	Public sector R and D organizations (PSRDO)	To find critical success factors for PSRDO and group them in hierarchical cluster and to integrate innovation ability and quality management
Statistical Quality Control and Process Capability Analysis for Variability Reduction of the Tomato Paste Filling Process	Industrial Engineering & Management (2014)	Dulce María Rábago-Remy, Edith Padilla-Gasca and Jesús Gabriel Rangel-Peraza	Tomato processing factory	To reduce the variability of the canned tomato paste filling process coming from a tomato

				processing food industry that has problems with the net weight
Improving Hospital Performance by Use of Lean Techniques: An Action Research Project in Brazil	Quality Engineering (2015)	Moacir Godinho Filho, Artur Boschi, Antonio Freitas Rentes, Matthias Thurer, Thiago Moreno Bertani	Surgery department of a Brazilian hospital	To reduce delay in surgery due to the lack of materials and a reduction in post-surgery infection

Based on above review in various industries a comparative analysis can be carried out to find the application of the methodologies described above. The analysis can be briefed as follows:

TIME AND METHOD STUDY:- Very much suitable for small scale industries but even large scale industries also has to pass through this step as it always the pioneer step for all methodologies. Case examples are manufacturing units, almost all small scale industries, etc.

LEAN MANUFACTURING: - Good strategy for medium and small scale industries and for those industries trying to get in the competitive market. Cost oriented methodology, results may take time but improvement is certain if applied properly. Case examples are Die Casting Industries, Manufacturing sector, Fertilizer industries, quality improvement, etc.

SIX SIGMA: - Suited for the industries seeking break through improvement. Has find applications in variety of sectors other than manufacturing sector. Case examples are casting industries, Hospitals, IT sectors, Public Sector Units, Manufacturing Industries, etc.

CONCLUSION

The purpose of this paper is to describe similarities and differences, methodology, advantages and barriers to implement Time Study, Method Study, Six Sigma and Lean. The presented concepts have many similarities, especially concerning origin, methodologies, tools and effects. Moreover the steps to implement the above methodologies also looks quite similar to each other, but it can clearly be seen that these Quality and Productivity Improvement Methodologies have different levels of outcomes. Also based on the requirements and available resources the methodology has to be selected to get the best possible outcome. Ideally for continues improvement Lean tools and techniques are preferred as its implementation takes relatively longer time but the advantage is that very less investment is required. Whereas Six Sigma is targeted to get break through improvements and has immediate outcomes but vigorous costing and analysis using statistical tools is required. It is recommended that for a small scale industry should go for Work Study before applying any of the IE techniques as some of the problems will be removed automatically and also hidden problems comes into the picture. It has to be noted that there are various studies available which combines Lean tools and Six Sigma commonly known as Lean Six Sigma (LSS) to capture all the advantages of both the methodologies. The industry can develop its own LSS model to achieve superior performance in competitive priorities like quality, reliability and speed. Few more case studies are to be studied to get the relative advantages of LSS over Lean Tools or Six Sigma.

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