# Review on Reduction of Delay in manufacturing process using Lean six sigma (LSS) systems

**P.Arunagiri*, Dr A.Gnanavel Babu ****

*Asst Professor & Research scholar, Sri Balaji Chockalingam Engineering College, A.C.S Nagar Irumbedu –Arni T.K, Tamil Nadu, India
** Professor & Head, Dept of Automobile Engineering, Karpaga Vinayaga College of Engineering and Technology, GST Road, Maduranthagam Tk, Kancheepuram Dist-603 308, Tamil Nadu, India.

***Abstract-*** Lean Six Sigma is a tool that can reduce muda (waste) during the manufacturing process. Lean Six Sigma is an integration of Six Sigma and Lean Manufacturing, both quality improvement techniques. Lean and Six Sigma are highly complementary and Six Sigma provides an integrated improvement approach that increases quality by reducing variation, defects, and costs. Lean adds tools that increases process throughput by eliminating waste. There are 7 types of waste that occurs during the production systems such as delay, conveyance, over processing, correction, conveyance so on and Delays occurs in the day to day process during manufacturing. But in process terms, delays are one of the biggest causes of ineffectiveness, inefficiencies, and poor performance. Hence, this paper mainly focus on various process methodologies that are used to reduce the delay in the manufacturing process in order to improve the productivity of the manufacturing systems.

***Index Terms***- Lean six sigma, Muda, Process delay, Process Improvement**.**

## I. INTRODUCTION

Lean six sigma is a technique and also an effort that is used to minimize the cost of the process by eliminating the waste in various service sectors. Lean philosophy identifies and removes the inefficiencies like the non value added (waste) cost or unneeded wait time within the process caused by defects, excess production and other process to expand any organization. Here discussed about the various types of waste that reduces the efficiency of the systems such as Errors and Defects, Wasted Motion/Unutilized Talent, Excess Inventory Processing and Complexity, Transportation, Delay and Wait Time, Overproduction. Mostly 80% of process delay are caused by 20% time trap .By improving 20% of time trap, it can eliminate 80% delay. Here the lean is associated with speed, efficiency, and acceleration of process. Defining delay as: to stop, detain, or hinder for a time; to move or act slowly; to cause to be late or behind in movement or progress. Synonyms include: retard, slow, slacken, detain, put off, and postpone. As we can see, none of these are particularly flattering terms for the process. Process improvement is about prioritizing problems and fixing only those that improve global outcomes. It is not about fixing any problem that arises. In fact, you may be better off leaving some problems as problems because there are more important uses of your time.

## II. MILESTONES OF LEAN PRODUCTION SYSTEMS

The mass production concepts were developed in the U.S. and established by Samuel Colt and Henry Ford [7,8], and the lean production is basically emerged from the innovations in the Toyota production System (TPS) in Japan since the 1940s [19] especially the just-in-time (JIT) delivery of materials between work stations to minimize Inventory systems. Most of the past reviews of lean are available e.g., Hines et al.& Holweg, [10,9],. Sugimori et al. [11] quote the first theory about the TPS, emphasizing JIT production and the use of good thinking by all employees to continuously improve performance. Most of the papers on JIT and the TPS emerged in the 1980s (Ohno, 1988; Shingo, 1989) [,21,20].According to Hopp and Spearman, Ohno [12,21]described the TPS as designed for continuous flow and based on two main principles: autonomation (best practices and standard work) and JIT (kanban and level production). Autonomation gives rise to practices pertaining to visual control, mistake proofing, and housekeeping (or ‘‘5S’’sort, straighten, sweep, standardize, and self-discipline), while JIT drives changeover reduction.[27]

The term ‘‘lean production’’ was first used by Krafcik [14] and popularized by Womack et al. [8] To some, lean is just a repackaging of JIT. For example, according to Hopp and Spearman , Womack et al. [12,8] ‘‘freshened JIT by recasting it as ‘Lean manufacturing.’’’Gaither and Frazier [13] equated lean with ‘‘the philosophies and approaches embodied in JIT.’’ Krafcik and McLachlin [14] viewed lean and JIT as closely related. Lean manufacturing focuses on the elimination of wastes from an organization’s operations through a set of work practices to produce products and services at the rate of demand (Womack etal; Fullerton etal., [8,22], Lean manufacturing represents a concept that may be grouped together as distinct bundles of organizational practices [23].Most sources describe the essence of lean production as waste reduction’’ [12] .Ohno’s ‘‘main focus was to reduce cost by eliminating waste’’ [9]This emphasis on waste reduction drove practices such as inventory reduction (e.g., Hall, 1983a,b), process simplification (e.g., Hall, 1983a) and the identification and elimination of non-value-adding tasks[18] , for which Womack and Jones [8] classified tasks into three types: 1. Those that add value (by directly transforming the product into the form desired by its user), 2. Those that do not add value but are necessary with current production methods(‘‘Type 1 muda’’), and 3. Those that do not add value and are unnecessary (‘‘Type 2 muda’’ or ‘‘obvious waste’’). Some authors have given prominence to other key practices in their definitions of lean, such as respect for people quality management,(e.g., Brown and Mitchell, 1991; [17] pull production (e.g., Brown and Mitchell, 1991),After examining the literature on lean, Narasimhan et al. (2006) [6] noted that ‘‘the essential aspect of leanness is the efficient use of resources through the minimization of waste’’ (emphasis in original) and defined lean as production ‘‘accomplished with minimal waste due to unneeded operations, inefficient operations, or excessive buffering in operations.’’ Indeed, ample scholarly sources have concluded that efficiency through waste and buffer minimization is the hallmark of lean. [27]

Hence, Womack and Jones' later work [8] turned its focus to lean implementation, moving from ‘‘what’’ to ‘‘how’’ [9] Through this work, Womack and Jones (2003) [8] distilled five principles of lean: (1) specify value in terms of the ultimate customer; (2) identify all of the tasks required to get a product or service to that customer – i.e., map the value stream – and eliminate the non-value-added tasks; (3) create continuous, single-piece flow wherever possible; (4) only flow product when a customer pulls it; and (5) seek perfection through an environment of continuous improvement. As it became better understood, lean grew from a focus on JIT and other specific practices performed in the TPS into an overarching philosophy or paradigm of world-class operations. Recent emphasis has been put on approaching lean using a scientific method [15] as part of a dynamic learning capability . [8] .Hines et al. [10] noted that many criticisms of lean fail to acknowledge its continuing maturation. [27]

## III. MILESTONES OF SIX SIGMA

Six Sigma programme was first launched at Motorola in 1986,by the joint efforts of some key persons among which Mikel Harry (Senior Engineer of the Government Electronics Group), BillSmith (VP and Senior Quality Assurance manager) and Bob Galvin (CEO).‘‘Motorola invented The Six Sigma quality improvement process in 1986. Sixsigma provided a common worldwide language for measuring quality and became a global standard.(Source: www.motorola.com;other sources frequently report that the official launch of Six Sigma took place in 1987).This leads to the Motorola to become the First American company to win the Malcolm Baldrige Quality Award, in 1988.[26] The Six Sigma methodology, mainly to improve manufacturing processes,has been then be revised by General Electric, in the mid-90s, first in the form of a Total Quality programme,to be then promoted to the rank of ‘‘managerial approach’’ by which to manage the entire organization. Any Six Sigma implementation aims at improving customer satisfaction, by mean of improved processes capability. This, in Turn, is made possible by focusing on ‘‘Critical to Quality’’ (CtQ) characteristics and implementing improvement actions seeking to continuously reduce processes variability in terms of CtQ. These actions are carried out by involving every employee. [25]

## IV. LEAN SIX SIGMA

Lean Six Sigma as a combination of Lean which eliminates wastes and Six Sigma which reduces variation. The focus is to use the knowledge of the workers with the proper tools to design, improve, and control the key processes of the product manufactured. In addition, management must provide a business process involving planning and strategic thinking. Looking at Lean and Six Sigma separately, each gives priority to different items of organizational performance .Resulting in diminishing returns Arnheiter, & Maleyeff, [3] However, with the implementation of both Lean and Six Sigma together, the returns can be on-going as shown in Figure 1 (Arnheiter, & Maleyeff, [3] Lean approaches focus on reducing cost through process optimization. Six Sigma is about meeting customer requirements and stakeholder expectations, and improving quality by measuring and eliminating defects. The Lean Six Sigma approach draws on the philosophies, principles and tools of both. However, Lean Six Sigma's goal is growth, not just cost-cutting. Its aim is effectiveness, not just efficiency.” Bryne et al. [6]

## V. TYPES OF WASTE

### *A. Overproduction*

Parts are being produced without any new order or demand from the customer. Excess products may be sold with reduced prices at the end of the industry fiscal year to match the budget or lower the inventory for the next year's production. [25]

### *B. Delay and Wait Time*

Some common wait time is caused by processing delays, machine or system downtime, response time, or signature required for approval wait time. One may consider the question: How much time value could be added if wait time was transformed into beneficial or work time? The answer is: A huge amount! Likewise, here are some wait time value-added questions.Why is the delay happening.,Are you waiting for materials, the next machine to be ready, or extra help to complete the job.What needs to change to make the flow smooth and even.
Wait time = f (machine downtime, response time, signature approval, etc.) [25]

### *C. Transportation*

Transportation is defined as delivered to and from outside the factory warehouse facility. The transportation of finished goods normally is generated by poor plant process or necessary plant process layouts. Transportation = f (plant process layout, travel distance, etc.)

### *D. Processing and Complexity*

Storing work-in-process (WIP) products in further locations adds unneeded processing steps to complete the project and more. Processing =f (WIP, old machine malfunction, needed process steps, WIP location, and so on)) [25]

### *E. Excess Inventory*

Excess inventory is called storing excess products with no orders in the warehouse and having excess WIP. This will impede and tie up the cash flow. In fact, it may end up creating a negative cash flow. Inventory = f (cash flow, order, production, floor space, etc.) [25]

### *F. Wasted Motion/Unutilized Talent*

Movements that may cause injury in the manufacturing environment will result in process delay. Other unutilized talents are employee lost time, unused skills, employee ideas, and recommendations in simplifying the process.Wasted motion = f (injury, operator experience, mismatched operator talent, inefficient assignment to an experienced operator, lost time, etc.) [25]

### *G. Errors and Defects*

Defects will add additional rework, inspection (both expensive and time consuming), design changes, process changes, and machine downtime to analyze problems. In the plastics industry errors and defects include mold qualification time; engineering design will require additional time. The original cost must be absorbed, and unnecessary rework or replacement costs need to be captured. )(pascal dennis , newyork press,2008) [25] Defects = f (rework, inspection, process changes, design changes, scrap, paperwork, etc.)

## VI. CHARACTERISTICS OF DELAY IN MANUFACTURING PROCESS

### *A. Elimination of process delays*

Most delays occur at transition points from one process step to another. By reducing the number of transitions or process steps we can significantly reduce delays. Research has shown that providing equal capacity at all steps within the process is the best way to eliminate delays. Adding flexible capacity for potential changes in demand at only one step will lead to increasing delays downstream later in the process. Thus you should make every effort to design in equal capacity at all steps within your processes to eliminate delays.

### *B. Comparison of bottle neck to delays*

A bottleneck is a type of delay where a process step has less capacity at its input than is demanded. As such, it determines the overall velocity or speed of the whole process. Any changes made to improve individual steps of a process, without addressing the bottleneck, are likely to fail to improve the process at all. Start by analyzing the process using a process map to identify the bottlenecks and delays. The aim is to identify where the flow slows within the process. Note that the bottleneck is not necessarily the step with the largest queue. Bottlenecks frequently occur when many sources merge into a single narrow channel.

### *C. System that Produces the Results*

The outcomes you receive from a process come from the design of the process. One major cause of poor process performance (waste) is delay. So we want to eliminate delays the best we can but, first we have to understand the delays before making any changes (quantitatively measure them). If delays are caused by bottlenecks then optimize the process (redesign) for bottleneck. You now have a step-by-step method for improving your processes in a continuous manner.

## VII. REDUCTION OF DELAY USING VARIOUS PROCESS IMPROVEMENT METHODS

Process Improvement: Process improvement is about resolving global issues or outcomes for the whole system of processes. It's about focusing on the customers' outcomes. To improve processes, you use a map, a process map, with a picture of the process interactions, outcomes, and activities involved. The process map helps you focus on what's important and what's not. The idea is to analyze the impact of any changes you make on the global outcomes and less on the local problem..Yet, human nature being what it is demonstrates that people spend 80% of their time on solving problems and only 20% on improving the process. It's the old Pareto principle (80/20 rule) again. Solving problems provides a sense of accomplishment, immediate gratification, and reward. Most compensation systems are based on problems solved instead of outcomes achieved.

### *A. Process Improvement by Design*

Process improvement is a result of changes made to a process' design. Well-designed processes produce outcomes that are expected, efficient, and keep customers happy. By comparison, solving problems does not focus on design at all. Instead, the focus is on patching the current design, reworking unexpected outcomes, or quick fixes to customer unhappiness. And it never ends. You will be constantly patching a bad design until the design is changed.

### *B. Process Improvement through Prevention*

Root cause is what we are looking for to change a bad design. Solving problems is a reactive approach seeking to understand and resolve the undesirable event. While, process improvement is a proactive approach seeking to understand the cause and stop the reoccurrence of an undesirable event. The only way to stop a reoccurrence is to change the design itself.

Many businesses solve problems that arise in reaction to operational events, management directions, tight deadlines, or complaints. In these situations fixing the problem is all that matters. There is no time to get at the root of the problem and prevent it from reoccurring.

### *C. Process Improvement through Simplification*

Process improvement is about process simplification. Reducing defects and variance or shrinking cycle times and speeding up a process involve removing needless activities, time delays or design flaws. On the other hand, solving problems usually adds steps. If you feel like you need to add an inspection step or more sign-off forms then you are problem solving. Problems do not have to occur. Thinking that they do is a problem solving mentality. Process improvement is about prevention and avoidance.

## VIII. CONCLUSION

Lean six sigma plays a major role in the reduction of non value added activities and especially delay in the manufacturing process lead to the inefficiency. To overcome this various process improve various bottleneck of the delay are identified and these delays are eradicated through the various steps such as process improvement by design,process improvement through prevention and process improvement through simplification. Usually process improvement is about identifying changes worthy of investment to implement permanently. In contrast, problem-solving results in short-term solutions due to its narrow focus on local problems and its "fix it" rather than "prevent it" approach. Even then, the numerous fixes just don't add up to significant gains. They are nothing more than isolated solutions with little connection to the organization's goals. Problem solving becomes a diversion, preventing an organization from making impactful changes. For problem solving to work, it needs to be a part of process improvement and problem solving will lead to further scope of research.

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## AUTHORS

**First Author** – P.Arunagiri, B.E,M.Tech, Asst Professor & Research scholar, Sri Balaji Chockalingam Engineering College, A.C.SNagar Irumbedu –Arni T.K, Pin : 632 317
Tamil Nadu, India. Email id - arunn79@yahoo.com

**Second Author** – Dr A.Gnanavel Babu , B.E,M.Tech,Phd, Professor & Head,Dept of Automobile Engineering, Karpaga Vinayaga College of Engineering and Technology, GST Road, Maduranthagam Tk, Kancheepuram Dist-603 308,Tamil Nadu, India. Email id - dr.agbabu@gmail.com