International Journal for Quality research
UDK- 658.5 / 006.83
Short Scientific Paper (1.03)

The Lean And Six Sigma Sinergy

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Abstract:*Many organizations, dealing with continuous improvement methods, have realized that Lean and Six Sigma methodologies complement each other. Lean manufacturing focuses on the removal of waste so that all processes in the total system add value from the customers' perspectives. The main emphasis of Six Sigma is the application of statistical tools in a disciplined manner, which requires data-driven decision-making. The integration of Lean and Six Sigma provides a synergetic effect, a rapid process improvement strategy for attaining organizational goals. When separated, Lean manufacturing cannot bring a process under statistical control, and Six Sigma cannot dramatically improve cycle time or reduce invested capital. Together, synergistic qualities are created to maximize the potential for a process improvement. The paper deals with Lean and Six Sigma principles and approaches used in modern manufacturing for process improvements, and bring forward benefits that are gained when these two methodologies are integrated.*

Keywords: Lean, Six Sigma, Continuous improvement, Process quality

1. INTRODUCTION

Lean and *Lean Six Sigma* are a set of methods companies can apply to any manufacturing, transactional or service process to reduce waste, eliminate non-value-added actions and cut time. *Lean* methods have a rich and proven history that began in the automobile industry at Ford in the 1920s in a rudimentary way and at Toyota in the 1950s in a more advanced way. Combining *Lean* with *Six Sigma* can produce a program that brings both short-term results - through the power of *Lean* - and long-term change through the power of *Six Sigma*. It is for this reason many companies are turning to a combined *Lean* and *Six Sigma* effort.

Lean means speed and quick action (reducing unneeded wait time).

Six Sigma means identifying defects and eliminating them.***Lean Six Sigma Engineering*** means best-in-class. It creates value in the organization to benefit its customers [1] and saves money without capital investment.

2. LEAN MANUFACTURING

Recently, there are many examples of successful applications of production improvement methodology know as *Lean* manufacturing or *Toyota Production System, TPS*. *Lean* manufacturing origins date back to the post-World War II era in Japan. It was developed by Taiichi Ohno, a Toyota production executive, in response to a number of problems that plagued Japanese industry. The main problem was that of high-variety production required to serve the domestic Japanese market. Mass production techniques, which were developed by Henry Ford to economically produce long runs of identical product, were ill-suited to the situation faced by Toyota. At the time, mass production is characterized by large overproduction and excess inventories which are pushed through production processes. Production is inflexible, usually producing one type of products in huge quantities. Today the conditions faced by Toyota in the late 1940s are common throughout industry and *Lean* is being adopted by businesses all over the world as a way to improve efficiency and to serve customers better.

Lean manufacturing is a proven approach to reduce waste and streamline operations. *Lean* manufacturing embraces a philosophy of continually increasing the proportion of value added activity of their business through ongoing waste elimination. A *Lean* manufacturing approach provides companies with tools to survive in a global market that demands higher quality, faster delivery and lower prices [2]. Specifically, *Lean* manufacturing:

- Dramatically reduces the waste chain
- Reduces inventory and floor space requirements
- Creates more robust production systems
- Develops appropriate material delivery systems
- Improves layouts for increased flexibility.

3. MAIN LEAN PRINCIPLES

Lean manufacturing principles provide a way to specify value, line up value-creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively. *Lean* manufacturing is based on five main principles [3]:

- **Value** for specific product should be precisely specified.
- The **value stream** for each product should be identified.
  - <u>*Value stream*</u>**:** Actions that add value to a product or process.
- Value **flow** should be made without interruptions.
  - <u>*Flow:*</u> The continuous movement of product, favouring single-piece flow and work cells versus production lines.
- The customer should **pull** value from the producer.
  - <u>*Pull:*</u> Replacing only material that is used and eliminating excessive inventory.
- Production perfection should be persuaded **continuously**.
  - <u>*Continuous Improvement:*</u> A relentless elimination of waste on a never-ending basis.

3.1 Product value

Value is what customers want or need, and are willing and able to pay for. A key *Lean* principle is to understand the nature and degree of value that the market demands. Exactly knowing the product value on market, as well as component of product value enables specification of value flow or value stream.

3.2 Identification of the value stream and removal of inessential operations

A value stream involves all activities, both value added and non-value added, required to bring a product from raw material into the hands of the customer, Figure 1.

In *Lean* manufacturing it is necessary to define true value stream for every product and to eliminate non-value added activities, which are usually divided into following seven categories, also known as *seven wastes* in manufacturing [4]:

- ***Overproduction*** - producing more than the customer will buy which leads to excessive inventories.
- ***Waiting*** – excessive time waiting to proceed to the next step in the process, or idle time.
- ***Transportation*** – the unnecessary movement of material or product.
- ***Over-processing*** – unnecessary or inefficient operations.
- ***Inventory*** – excess inventory of parts and materials before they are required.
- ***Motion*** – non-value added movement of workers and equipment.
- ***Producing defective products*** – excessive defects and rework of materials, labour and overhead.

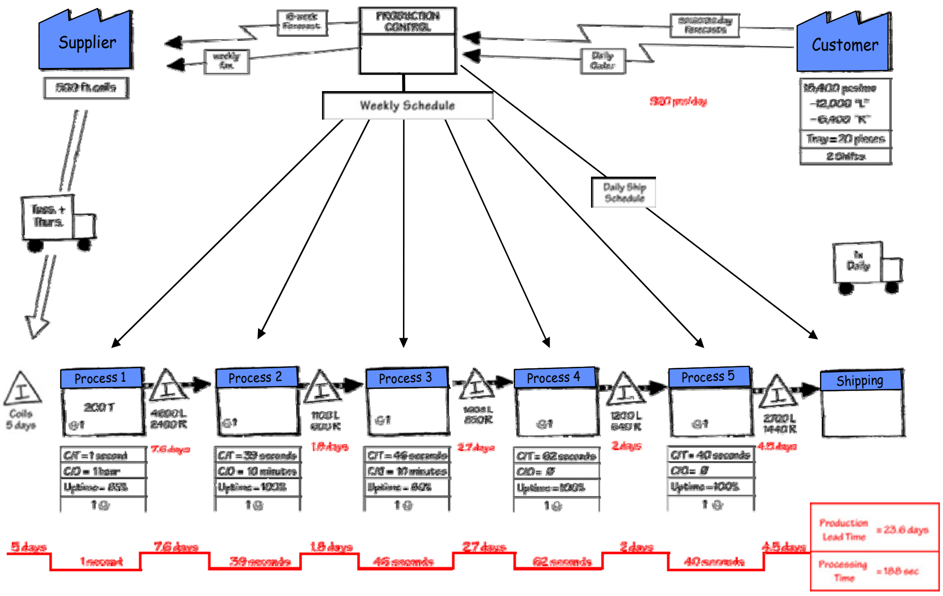

Figure 1. The Value Stream

In average, less than 1 % of activity is value adding, and typically, resources are piled into improvement of the 1 % and ignore the 99 % opportunity, Figure **2.**

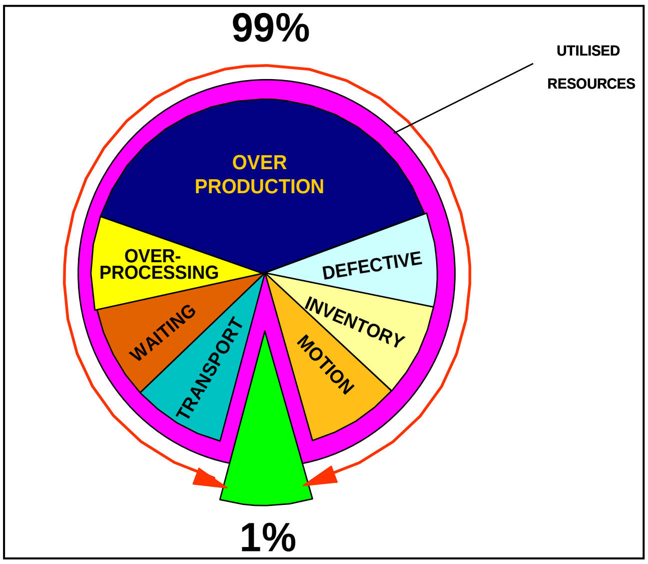

Figure 2. Seven wastes in manufacturing

3.3 The value flow

The key to value flow is the customer's requirements. What the customer needs and when he needs it drives all activity. The *Lean* ideal here would be continuous one-piece flow of intermediate products rather than batch production.

3.4 The customer pulls value from the producer

In essence of *Lean* manufacturing is that product should be produced only when customers needs it. When user of products or last customer in production chain pull the product, Figure 3, each production process is triggered to produce needed product [5]. Flow focuses on the object of value, the product, design, service, order, etc. that is being created for the customer. All work practices are carefully evaluated and rethought to eliminate stoppages of any kind so the object of value proceeds smoothly and continuously to the customer.

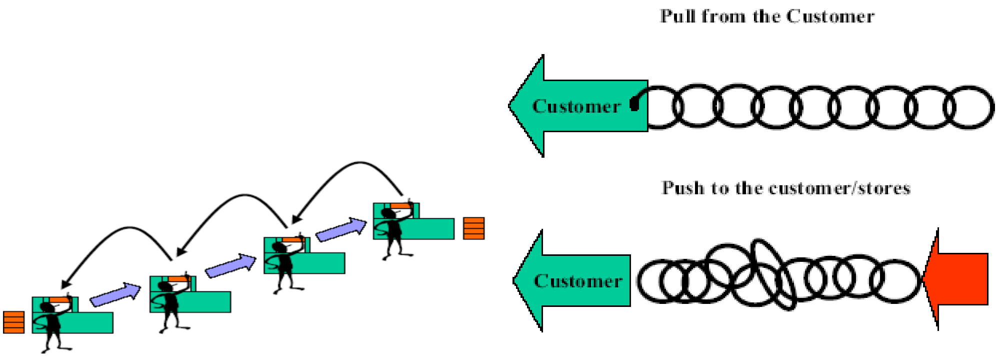

Figure 3. One-piece flow and pull principle of manufacturing

3.5 Continuous pursuit of perfection

One of the most important benefits achieved by *Lean* manufacturing is improved quality. With large batches of inventory many quality problems are hidden and only become visible when the downstream customers try to use the material and it does not fit. By this time the same problem has been made on many other plates or profiles and they are all somewhere in the pipeline [6]. *Lean* manufacturing emphasizes the efficient use of resources that shortens lead times and decreases costs by eliminating all non-value waste. Also, it is critical to understand that no level of performance is ever good enough, and that there is always room for improvement.

4. MAIN SIX SIGMA PRINCIPLES

Six Sigma methodology formally emerged at Motorola in the 1980s although some authors imply that Motorola first embarked on its *Six Sigma* quality initiative in the mid 1960s. Motorola's specific involvement with *Six Sigma* began when it implemented a quality-improvement program focused on manufacturing. Their approach was based on rigorous Japanese theories of TQM for use in the manufacturing process, where defects are relatively easy to spot and count [7]. Strongly supported by company's top management, *Six Sigma* initiative was spread throughout the company.

Soon, *Six Sigma* training was required for every employee. Every single person was expected to understand the process and applied it to everything that they did [8]. While the original goal of *Six Sigma* was to focus on the manufacturing process, it became clear that the distribution, marketing and customer order processing functions also needed to focus on reaching *Six Sigma* quality standards and eliminating defects throughout the organization's processes [9].

The main objective of *Six Sigma* initiative is to aggressively attack costs of a quality. Tools and methodology within *Six Sigma* deals with overall costs of quality trying to minimize it, while, in the same time, increasing overall quality level contribute to company business success and profitability.

Six Sigma is a philosophy of doing business with a focus on eliminating defects through fundamental process knowledge. *Six Sigma* methods integrate principles of business, statistics and engineering to achieve tangible results.

Six Sigma tools are used to improve the processes and products of a company. They are applicable across every discipline including: Production, Sales, Marketing, Design, Administration and Service.

Six Sigma offers a wealth of tangible benefits. When skilfully applied *Six Sigma*:

- Reduces costs by 50 % or more through a self-funded approach to improvement
- Reduces the waste chain
- Affords a better understanding of customer requirements
- Improves delivery and quality performance
- Provides critical process inputs needed to respond to changing customer requirements
- Develops robust products and processes
- Drives improvements rapidly with internal resources.

Six Sigma has a number of unique strengths, explaining in part both the endurance of its appeal and the demonstrated power of the approach. Among these are the infrastructural elements and career development paths that were developed and added to *Six Sigma* under Jack Welch at GE and Larry Bossidy at Allied Signal (now Honeywell). A strength of *Six Sigma* related to this is the presence of dedicated resources, namely Black Belts, in addition to the general expectation that everyone will be involved. Finally, the structure to improvement projects provided by DMAIC and the use of gated reviews at the end of each DMAIC phase is two additional strengths unique to *Six Sigma*.

5. LEAN AND SIX SIGMA

Both the *Lean* and the *Six Sigma* methodologies have proven over the last twenty years that it is possible to achieve dramatic improvements in cost, quality, and time by focusing on process performance. In the past several years many organizations realized that *Lean* and *Six Sigma* methodologies complement each other. The main emphasis of *Six Sigma* is the application of statistical tools in a disciplined manner, which requires data-driven decision-making. *Six Sigma* is about controlling processes to get the desired results. The target process can be any process critical to customer satisfaction and bottom line benefits [10].

Lean is primarily concerned with eliminating waste and improving flow by following the *Lean* principles and a defined approach to implement each of these principles. However, using either one of them alone has limitations: *Six Sigma* will eliminate defects but it will not address the question of how to optimize process flow; and the *Lean* principles exclude the advanced statistical tools often required to achieve the process capabilities needed to be truly 'lean'. Therefore, most practitioners consider these two methods as complementing each other to achieve world class performance (WCP). Mathematically the WCP is the output response defined as a function of *Lean* and *Six Sigma*. In other words, WCP is dependent on *Lean* (y_L) and *Six Sigma* (y_{SS}). Thus, as a mathematical function:

WCP = *f* (*Lean* causes of variation, *Six Sigma* causes of variation)

$$\text{Output} = f\,(\text{Input}) \qquad (4.1)$$

or

$$Y_{WCP}\ (\text{or } Y_{LSS}) = f\,(y_L\,,\, y_{SS}) = f\,[\, f_L\,(x),\, f_{SS}\,(x)] \qquad (4.2)$$

where Y_{WPC} is world class performance response and Y_{LSS} is *Lean Six Sigma* output. Y_{LSS} is a function of second round of measurements y_L (*Lean* output) and y_{SS} (*Six Sigma* output).

The process of the *Lean Six Sigma* model is shown in Figure 4 [1].

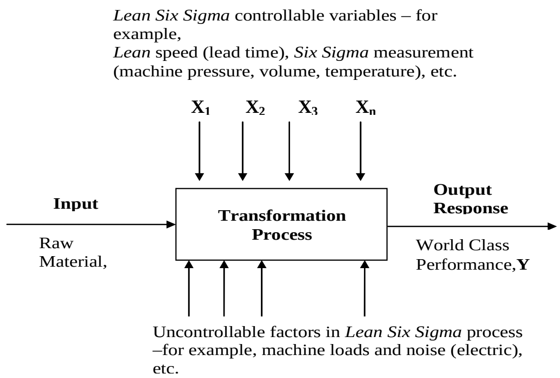

Figure 4. General model of Lean Six Sigma processs

The integration of *Lean* and *Six Sigma* provides a rapid process improvement strategy for attaining organizational goals. Together, synergistic qualities are created to maximize the potential for process improvement, Table 1 [11].

Bringing the two concepts together delivers faster results by establishing baseline performance levels and focusing the use of statistical tools where they will have the most impact. Most companies using both methodologies began by applying basic *Lean* - manufacturing techniques - the 5Ss, standardized work and the elimination of waste. Once *Lean* techniques eliminate much of the noise from a process, *Six Sigma* offers a sequential problem-solving procedure, the MAIC cycle, and statistical tools so that potential causes are not overlooked and viable solutions to chronic problems can be discovered.

Table 1. The synergy of Lean and Six Sigma

Lean contribution	Six Sigma contribution
Established methodology for improvements	Policy deployment methodology
Focus on customer value stream	Customer requirements measurement, cross-functional management
Project-based implementation	Project management skills
Understanding current conditions	Knowledge discovery
Collect product and production data	Data collection and analysis tools
Document current layout and flow	Process mapping and flowcharting
Time the process	Data collection tools and techniques, SPC
Calculate process capacity and Tact time	Data collection tools and techniques, SPC
Create standard work combination sheets	Process control planning
Evaluate the options	Cause-and-effect, FMEA
Plan new layouts	Team skills, project management
Test to confirm improvement	Statistical methods for valid comparison, SPC
Reduce cycle times, product defects, changeover time, equipment failures, etc.	7M tools, 7 QC tools, DOE

The integrated approach to process improvement using *Lean* and *Six Sigma* will include:

- Using Value Stream Mapping to develop a pipeline of projects that lend themselves either to applying *Six Sigma* or *Lean* tools.
- Teaching *Lean* principles first to increase momentum, introducing the *Six Sigma* process later on to tackle the more advanced problems.
- Adjusting the content of the training to the needs of the specific organization - while some manufacturing locations could benefit from implementing the *Lean* principles with respect to housekeeping, others will have these basics already in place and will be ready for advanced tools.

The main point of effective application of continuous improvement process is to get team working together on processes that are important to their company and its customers. By doing so, they have to achieve goal of **delighting customers** by delivering higher quality service in less time. That can be done by **improving** related business **processes** eliminating defects and focusing on how the work flowed through the process. The team members should be from the different process areas, and their decisions should be based on data and facts. On Figure 5 are shown basic four pillars of *Lean Six Sigma* [12]. It is needed all of elements, working together, to create real solutions. Any of the elements alone isn't enough. The goal can be achieved only if the creativity of the people is used in team work on the processes with data and with an understanding of customers and processes.

6. CONCLUSION

Lean manufacturing is a philosophy, a way of thinking, not a set of individual tools. Moreover, *Lean* manufacturing requires an enterprise-level view of the value stream, from raw materials to the finished product delivered to the customer. *Lean* production is a philosophy but what is most important is the process of involving associates in reducing the production flow by eliminating waste. If people are solving problems and continuously driving out waste then *Lean* manufacturing is alive and well.

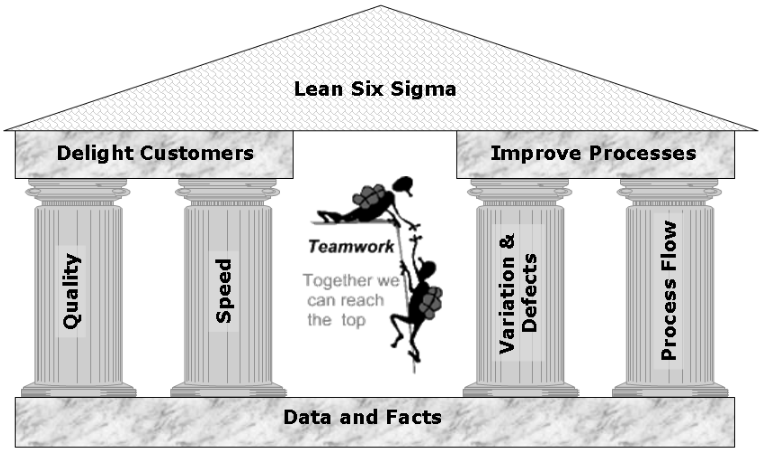

Figure 5. The Pillars of Lean Six Sigma

Typically, when one company or one national industry commits to *Lean* principles and practices, competitors who do not become *Lean* are in trouble. They find themselves losing market share, profits and even the business itself. Together, *Lean* and *Six Sigma* are capable for improving performance of processes and a culture of continuous improvement.

An integrated *Lean* Six *Sigma* approach, learning and drawing from the best of its historical roots, is the next evolutionary state in the area of process performance improvement. It builds and improves on *Lean* and *Six Sigma* just as these traditions built and improved on TQM which built and improved on SPC and so on back into history. The demands of the modern marketplace for greater and greater levels of value, that all organizations offerings become ever better, cheaper, and faster, show no signs of abating. In order to meet those demands and still survive, and even thrive; organizations have to marshal the best methods in continuous improvement.

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Received: 03.09.2008 Accepted: 08.10.2008 Open for discussion: 1 Year