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A MODEL OF LEAN – SIGMA TO ENHANCE A MANUFACTURING SYSTEM THROUGH INTEGATING LEAN MANUFACTURING AND SIX SIGMA APPROACHES

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THESIS

Presented to the Faculty of the Graduate School of

The University of Texas at El Paso

in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE

Department of Mechanical and Industrial Engineering

THE UNIVERSITY OF TEXAS AT EL PASO

August 2008

Acknowledgements

I here by specially thank Dr. Bill Tseng for his guidance and support throughout my research. They have been extremely nice and helpful and favorable to me in all my endeavors during my work on this thesis without whom it would be hard to have reached my goals. I would like to express my gratitude to my family and friends Smitha Paramanandan and Gautam Acharya for their support. I also like to thank Dr. Jeanmai Zhang and Dr. Tim Yao for being the members of my Supervising Committee.

I take this opportunity to extend a special thanks to Dr. Bill Tseng, who has been a great mentor. He has given me great support and inspiration to progress with my ideas and thoughts which has led to successful completion of this thesis.

Abstract

Six Sigma aims at reducing defects by reducing variability in the system which is its primary concentration; while Lean Manufacturing aims at reduce/eliminate waste where reducing defects through variability could be one or more of its concentration. While many organizations are using either Six Sigma and/or Lean Manufacturing independently there is no real research to use them in unison as Lean Sigma instead of using them as two independent bodies for continuous Improvement. This Thesis attempts to integrate Six Sigma and Lean Manufacturing to propose a model for Lean Sigma which will allow using the tools of Six Sigma and Lean Manufacturing to reduce/eliminate waste by working in unison rather than independently.

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Chapter 1

Introduction

1.1 Background

Lean manufacturing is American name to Toyota Production System which was introduced by Toyota in the 1980's which the rest of world follows as lean manufacturing today. Lean manufacturing is considered to be one of most advanced manufacturing concepts today which have expanded its application and use from manufacturing to other business sectors such as business processes, transactions and services bringing in the name lean enterprise where lean manufacturing can also reside.

While lean manufacturing was being found by Toyota another concept called six sigma was taking birth and growing up in Motorola. Six sigma was found by Motorola in late 1980's. Six sigma is considered an extension of quality movement started decades before six sigma was born as a concept. Six sigma is the most popular quality movements in the industry. Six sigma is a highly focused project based process improvement approach that is strongly backed and sponsored by management. Six sigma like lean manufacturing has expanded its applications to other industries besides manufacturing where it was originally introduced.

Lean manufacturing and six sigma with their widespread and effective application and outstanding results are being considered as powerful business methods rather than set of

manufacturing methods or tools. With proven results of these two approaches is emerging another approach called lean six sigma which attempts to reap the benefits of these two successful tested methods to increase the velocity, intensity and effectiveness of results. Lean six sigma or sometimes known as lean sigma is quickly emerging as a business need rather than process improvement tool, however there is not enough work done to unite the two to understand the effective use of the two approaches in unison as one single method or approach.

1.2 Thesis Overview

The objective of this thesis is to find a model that can combine two powerful process improvement approaches namely lean manufacturing and six sigma which have not only revolutionized the present manufacturing industry but also most other business sectors. Lean manufacturing is used to eliminate waste such that it creates value to the customer, while six sigma is used to eliminate defects to create a defect free environment which also would also eventually create value to the customer. Though the end result of both the approaches are to achieve better business results through improved processes, products, and quality that is valued by the customer, their focus and tools are more streamlined to problem solving techniques that do not provide 100% utilization of their true potential. A model is required that starts and ends with the bottom-line business goals that would result in better business by exploiting the two disconnected approaches on a common ground which are united by a common purpose which is better business results.

It is a well known fact that any key indicator of any business performance is directly or indirectly related to the customers catered by the business. Hence the best starting point is to understand the needs of the customers the business caters to and satisfy the customers or the customer base which eventually nourishes and improves the same very business. This is the guiding principle in combining the lean manufacturing and six sigma approaches to create a lean sigma model.

The proposed lean sigma model uses the tools and concepts of both lean and six sigma approaches to suggest a model called VDMAICP which stands for value, define, measure analyze, improve, control and perfection where the key guiding principle is identifying and improving value from the customer's perspective. The model also defines a lean sigma line explaining the direction of progress for the model and the point which describes the ultimate goal when perfection is achieved.

1.3 Thesis Organization

Chapter 2 describes the literature reviewed in the areas of lean manufacturing, six sigma and lean six sigma. Basic underlying concepts of these approaches are explained in this chapter.

Chapter 3 covers the methodology proposed by the author to combine lean manufacturing and six sigma approaches to lean sigma approach. The basis of the model is explained in the chapter. This chapter explains the method used to combine the two approaches.

Chapter 4 explains the integrated model which is proposed in chapter 3. Detailed description of how the model is formed is explained in this chapter. This chapter starts of by explaining lean

manufacturing and six sigma methodology and concepts in chapter 4.1 and 4.2 and then explains how they can be combined in chapter 4.3.

Chapter 5 covers the results and discussion on the integrated lean sigma model explained in the earlier chapters. Applications, constraints and benefits of the proposed integrated lean sigma model is explained in this chapter.

Chapter 6 discusses the final conclusions of the integrated lean sigma model and future work that can be accomplished with this model that the author has not been able to complete in this thesis.

Chapter 2

Literature Review

2.1 Lean Manufacturing

Lean Manufacturing defines the value of a product or a service from a customer point of view. Lean manufacturing emphasizes that customers are not willing to pay for the non value added activities that are inherent in a manufacturing system. They evaluate the product or service by reviewing how well their requirements are fulfilled by the product or service. Non value adds in a manufacturing systems are considered a waste. Defects are one of the kinds of wastes in the system. In Lean manufacturing waste is defined as anything does not add value to the end product from customer point of view.

The basic idea behind lean has been practiced for decades. Originally practiced by Henry Ford, later in Japan by Taiichi Ohno and Shigeo Shingo in the development of the well known Toyota Production System (TPS). Lean discipline works in every facet of the value stream by eliminating waste in order to reduce cost, generate capital, bring in more sales, and remain competitive in the global market. The value stream is defined as "the specific activities within a supply chain required to design, order and provide a specific product or value" [1].

Lean manufacturing has evolved from traditional manufacturing practices based on change in market needs and business models. History of various manufacturing practices in the last 4

decades is shown in the Table 2.1.1. Evolution of various manufacturing practices show that as market needs changes there is a need to adapt to the changing environments which can be seen in the changes in manufacturing styles, though their basic philosophies vary the basic idea of eliminating waste and creating value will still remain. Table 2.1.2 shows the key characteristics of each of these manufacturing stages [2].

Table 2.1.1 Evolution of Manufacturing Practices

Period	1970's	1980's	1990's	2000 & beyond
Manufacturing Practice	Push Manufacturing	Lean Manufacturing	Flexible Manufacturing	Adaptive Manufacturing
Key Market Differentiator	Cost	Quality	Availability	Lead Time
Performance Indicators	Production Throughput	Cost Management	Segment Market Share	Customer Satisfaction

Table 2.1.2 Manufacturing Processes

Manufacturing Practice	Characterstics	Philosophy
Push Manufacturing	Mass production	Maximize capacity utilization to lower costs
	Focussed Assembly Lines	Focus on avaiability and economics of scale
Manufacturing Practice	**Characterstics**	**Philosophy**
Pull (lean) Manufacturing	Produce only what is sold	Significant focus on product and process quality
	Flow philosophy	Production smoothing by lot size management
	Limited product variety	Enterprise metrics - across major functions
Manufacturing Practice	**Characterstics**	**Philosophy**
Flexible Manufacturing	Significant product variety	Ensure product availability at any cost
	Reduncancy availability	Accept variability - focus on economies of scope
	Focus on TOC principles	Enterprise metrics - across major functions
Manufacturing Practice	**Characterstics**	**Philosophy**
Adaptive Manufacturing	System integration for visibility	Compete on service and minimize lead time
	Enhance network collaboration	Cost and velocity of flexibility
	Manage by analytics	Collaborative metrics across business partners

Lean techniques helps control the amount of work in progress (WIP) by creating flow and pull which in turn would reduce the impact of problems on lesser parts as compared to batch processing as when problem occurs as in a batch manufacturing environment a batch is affected which increases variability in a batch rather than one part as in a lean environment pull and flow will not allow to make more parts than necessary by creating one piece flow. Fig 2.1.1 below [3] shows the comparison in variability as a result of a problem occurred in traditional batch vs. lean manufacturing environment.

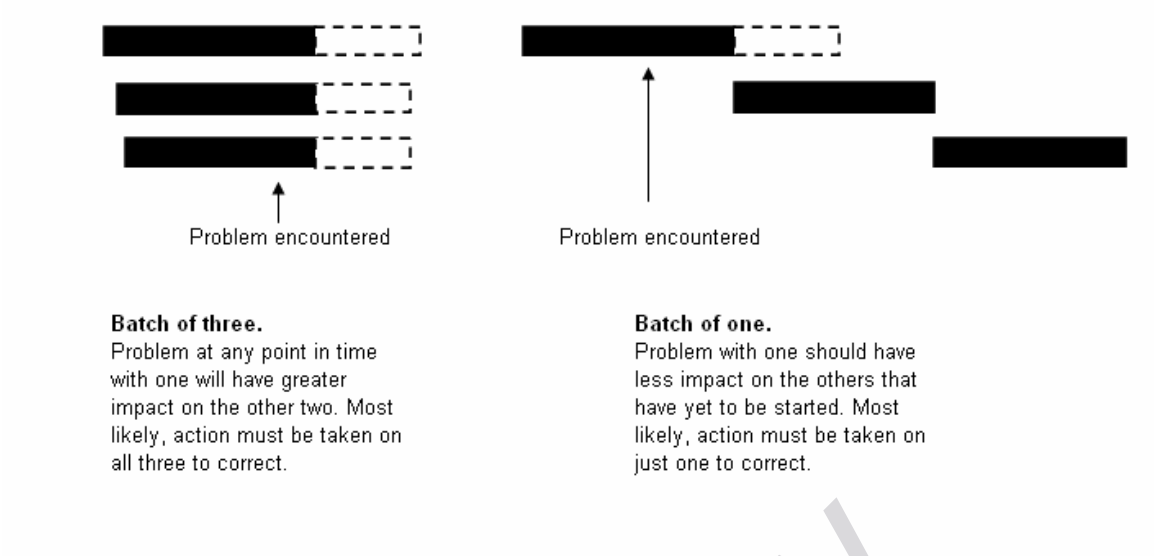

Figure 2.1.1 Batch vs. Lean Manufacturing Variability

Lean Thinking begins with the concept of muda which means waste in Japanese, specifically any activity which absorbs resources without creating value is waste. Lean thinking also provides a way to make work more satisfying by providing immediate feedback on efforts to convert muda into value. Lean thinking begins it process with value [4]. Wastes are considered to be of 8 types which are overproduction, waiting, work in progress, transportation, inappropriate processing, excess motion or ergonomic problems, defected products and underutilized employees. Wastes can be also categorized as,

- Avoidable wastes
- Unavoidable wastes

There are 4 key steps in implementing Lean manufacturing

a) Identifying the fact that there is wastes to be removed
b) Analyzing the wastes and finding the root causes for these wastes
c) Finding the solution for these root causes
d) Application of these solutions and achieving the objective

There are six fundamentals of lean production as described below,

a) The workplace is safe, orderly, and immaculately clean.
b) Products are built just on time, and only based on customer demand.
c) Six Sigma quality is built into the product and the process.
d) Empowered work teams make key decisions on the shop floor and for supporting functions.
e) Visual management techniques are used to spread critical information throughout the product facility.
f) There is a relentless pursuit for perfection

Lean framework or principles provided by Womack and Jones are,

- Specify *value* in the eyes of customer
- Identify the *value stream* and eliminate waste
- Make value *flow* at the *pull* of the customer
- *Involve* and *empower* employees
- Continuously improve in pursuit of *perfection*

Massachusetts Institute of Technology defines a lean enterprise as a business organization that delivers value to all its stakeholders with little or no superfluous consumption of resources where value is defined as capability to provide the customer what they want, at the right time, at an appropriate price or cost, as defined by each customer and resources could be materials, people, capital, time, physical facilities, equipment, information etc [5]. Massachusetts Institute of Technology (MIT), in collaboration with members of Lean Aerospace initiative (LAI) , has defined eight characteristics or dimensions for a lean enterprise [6] as stated below.

a) Strategy
b) Customer focus
c) Organizational structure
d) Incentives and performance scorecards
e) Lean management
f) Workforce issues
g) Enterprise business systems
h) Organizational learning

Though lean manufacturing is perceived to be merely a set of tools and methods used for improvements, it is a complete manufacturing system affecting the entire enterprise in every function. Lean thinking requires a strong commitment to lean management with the knowledge that great achievements occur by elimination of waste throughout the entire business operation. While Lean management systems vary from one enterprise to another, however they are all focused upon waste elimination through scientific approach, individual ingenuity, teamwork, just

in time information, commitment to continuous learning and innovation, and effective integration of social and technical systems [7]. A seven step process for organizations to use in order to become lean is listed below [6].

a) Enterprise strategic planning
b) Adopt lean paradigm
c) Focus on the value stream
d) Develop lean structure and behavior
e) Create and refine transformation plan
f) Implement lean initiatives
g) Focus on continuous improvement

Although most literature suggests that enterprise embracing lean has to understand that the path to lean is an endless never-ending journey. Lean can be challenge when it has to be grasped as a whole system rather than a process or activity; as a result some people cherry pick activities or processes to apply lean and their long term cultural change efforts fail. Lean activities must be a part of the holistic system or an integrated series of parts with a clearly defined goal. Each of these activities must have a defined purpose. These activities are interdependent and an understanding of how each fits into the system as a whole and interaction with each other is important to support the future success of the individual enterprise [5].

Lean enables a fundamental change in how the people within an enterprise think and what they value, eventually transforming how they behave. A lean enterprise understands and believes in

the fundamental virtue of the basic lean principles. Within a lean system everyone is focused on identifying and eliminating waste. The entire system looks through the eyes of the customer to understand customer perception of value and thus working towards creating that value. The true power of lean is in unlocking the potential of the entire enterprise to transform everything an enterprise does. A completely lean organization extends its transformation both ways upstream to its suppliers and downstream to its customers [5]. Lean has been applied not only to the shop floor, but in every aspect of an enterprise in many industries including medical, government, and other services.

In the book "Lean Thinking", Womack and Jones report possible improvements from initial conversion to lean as well as sustained overtime as a result of continuous improvement. The benefits and potential impacts of lean implementation illustrating the intensity of improvements that are possible as a result of initial lean implementation from a traditional manufacturing and intensity of improvements that are possible as sustenance through continuous improvement after initial improvements (at least about 3 years) are shown in table 2.1.3 below [8].

Table 2.1.3 Lean Thinking Improvements Estimates

Lean Thinking Improvements Estimates		
Improvement	**Initial Lean Conversion**	**Continuous Improvement**
Labor Productivity	Double	Double again
Throughput Time	90% Reduction	50% Further Reduction
Inventories	90% Reduction	50% Further Reduction
Errors Reaching Customers	50% Further Reduction	50% Further Reduction
Scrap	50% Further Reduction	50% Further Reduction
Time to Market, New Products	50% Further Reduction	50% Further Reduction