The Synergy Effect

Between Six Sigma & Lean Manufacturing

by

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ABSTRACT

The purpose of this study is to report the synergy effect between Six Sigma and Lean Manufacturing on a company's needs. The review of literature included problem statement; the background of Six Sigma and Lean Manufacturing in company needs. The research methods were used to collect data related to the effects of Six Sigma and Lean Manufacturing. Most companies want to save cost and increase profit. Just selling the product does not guarantee profit to companies any more. The companies also are concerned with surviving competition from rival companies. Today, business wars exist

between developed countries and developing countries. This research studies the synergy effect between Six Sigma and Lean Manufacturing utilized in the world business competition.

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Chapter I: Introduction

The purpose of this study is to report the synergy effect between Six Sigma and Lean Manufacturing. The review of literature included a problem statement about the background of Six Sigma and Lean Manufacturing. This study will focus on the effects of analysis from Six Sigma and Lean Manufacturing to determine potential areas of improvement. The decision on whether or not to deploy Lean Manufacturing is a good place to test the strength of Six Sigma.

For years, there have been debates over whether companies deliver what they promise. Today organizations look to improve their business processes. The main objective is increasing the productivity by decreasing the process variation, leading to defect reduction and vast improvement in profit, employee moral and product quality. Lean Manufacturing and Six Sigma have been known to be chosen process improvement methodologies and companies are looking at them as a new age mantra, which will improve variation.

A Six Sigma is a performance that applies to a single Critical- To-Quality (CTQ), not to the total product. It is important to pay attention to the processes, because final outcomes or results are dictated by what happens during the process. When businesses create a better process, they eliminate opportunities for defects before they occur. By reducing the variation during creation of the products and services, it's possible for any business to achieve Six Sigma quality.

Also, Lean Manufacturing allows competition in the areas of cost and delivering reliability by reducing labor and inventory cost. Lean Manufacturing focuses on lead-time. Manufacture companies save cost by shortening lead-time. Both Six Sigma and Lean Manufacturing give a chance to companies to compete business challenging.

Significance of the study

Generally both Six Sigma and Lean Manufacturing are only approached for their performance improvement and organizational transformation. If Six Sigma means detailed analysis during operating, Lean Manufacturing gives a big picture about whole operation. A Six Sigma and Lean Manufacturing are a strong strategy today and for the future in all business industries. Some companies only use Six Sigma for efficiency and effectiveness. Other companies just use Lean Manufacturing to save lead and cycle time, and to eliminate waste.

This study helps to understand easily the Synergy effect between Six Sigma and Lean Manufacturing, and the relationship between both. This study tries to find how both theories can integrate for their purpose.

Limitation

This study is limited by the following:

1. This study does not have specific information from companies.

2. Sample problem: One company data may not be a representative of all companies.

3. The result of this project cannot adapt to all of the companies.

4. This study does not provide specific research, survey, and interview

Definition

The following definitions were used in this study:

1. A Six Sigma is a term coined by Motorola that emphasizes process improvement by reducing variability and making general improvements. A Six Sigma quality level is said to equate to 3.4 parts per mission outside specification limits (Breyfogle, Cupello, and Meadows, 2001).

2. Critical to Quality is a characteristic of a product or service that is emtreamly important for a customer (Tom Devance, 2004. p. 357).

3. Cycle time is a time necessary for a machine or operator to complete all designated tasks before moving to the next operation (Andrew Berger, 2003).

4. Cycle Time is amount of time necessary to produce one good part through a

manufacturing operation (Andrew Berger, 2003).

5. Fishbone diagram is a visual analytical display (Andrew Berger, 2003).

6. Fixed cost is cost that does not vary with the level of production and remain even if an activity or process stops (Gary Conner 2002).

7. Flow chart is a graphical representation of process steps used for better understanding (Gary Conner 2002).

8. Just in Time is a production system that produces what is needed, when it is needed, in the amount needed (Gary Conner 2002).

9. Kanban is a Japanese term that translates to card, in which standard containers and lot sizes are used to replace customer demand (Breyfogle, Cupello, and Meadows, 2001).

10. Lean Enterprise is applying lean methodology to the entire workplace, from order creation to after sales service (Breyfogle, Cupello, and Meadows, 2001).

11. Lean Manufacturing is a production philosophy that incorporates the philosophies in JIT and applies them to the manufacturing environment (Gary Conner 2002).

12. Non-value added is activities or actions taken that do not add value t other product or service and may not have a valid business reason for being performed (Gary

conner 2002).

13. Plan-Do-Study-Act is an improvement cycle introduced by W.Edwards Deming that seeks to (1) determine goals and required changes to achieve them, (2) implement proposed changes, (3) evaluate the results obtained, and (4) take appropriate action such as starting the cycle again, standardizing, or stabilizing the change (Tom Devance, 2004. p.363).

14. Probability is a numerical assessment of the likelihood that an event will occur (Andrew berger, 2003).

15. Random sampling is the process of sampling where data points are selected totally at random. This approach to sampling is designed to reduce sampling bias (Andrew berger, 2003).

16. Sigma is The Greek letter sigma is used to express the standard deviation of a process. Standard deviation measures the variation or amount of spread about the process average. Six quality levels are sometimes used to describe the output of a process (Breyfogle, Cupello, and Meadows, 2001).

17. Value added activity is adding valued to an output product or service. An activity or process that changes the product into something a customer can use and is willing to pay for (Gary Conner 2002).

18. Value mapping analysis is analyzing the value stream to identify the ratio of value added to non-value added activities (Gary Conner 2002).

19. Variation is a change in data, characteristic, or function caused by either special causes, common causes, tampering, or structural variation (Gary Conner 2002).

20. Waste is anything that consumes resources, but does not add value to the product (Gary Conner 2002).

Problem Statement

All of business organizations are trying to stay competitive and profitable for a long-term period. Most companies try to reduce their cost, customer demands, and cycle time through the application of Six Sigma and Lena Manufacturing technologies. The purpose of this study is to identify how the business can obtain and develop a synergy effects between Six Sigma and Lean Manufacturing.

Assumption

Six Sigma and Lean Manufacturing technologies are applicable to most of all manufacturing companies related in any environment.

Chapter II: Review of Literature

Introduction

The review of this literature explained the relevance of this study. The literature review will cover two areas: one is to give overview and background of the Six Sigma and the other is an overview and background of the Lean Manufacturing

Background of Six Sigma

According to Breyfogel, the term Six Sigma first appeared at Motorola, where Six Sigma was developed and refined. A number of organizations have chosen to refer to their Six Sigma suing different names because the organizations hope to avoid any controversy or problem about the use of the term.

Jack Welch, CEO of GE, stated that Six Sigma focuses on moving every process that touches our customers' every product and service toward near perfect quality (In GE's Annual Report 1997). He also asked and recommended that all employees especially those who want to seek promotion and also senior executives be educated on the Six Sigma technique.

Breyfogel states that Six Sigma's business strategy is its focus on objectives. Also organizations can get so involved in counting and reporting of defects that they lose sight of the real value of Six Sigma, which orchestrates process improvement and reengineers it in such a way that they achieve significant bottom-line benefits through the implementation of statistical technique.

Pyzdek states that during the mid 1980s, Motorola figured out what to do about it. At that time, Bob Galvin, Motorola's CEO, began the company on the quality path known as Six Sigma. After the beginning, Motorola became know as a quality leader. Motorola's success became public knowledge and started the Six Sigma revolution. Sometimes Six Sigma is thought to be about traditional quality sense. Traditional quality is internal requirement; however, Six Sigma is different. Six Sigma is about statistical approach and improving customer value and efficiency. Pyzdek(2003) talks about the two kinds of quality definitions by stating, "For Six Sigma purpose I define quality as the value added by a productive endeavor. Quality comes in two flavors: potential quality and actual quality. Potential quality is the known maximum possible value added per unit of input. Actual quality is the current value added per unit of input. The difference between potential and actual quality is waste"(p.5).

Six Sigma focuses on improving quality by helping organizations produce. Therefore, Six Sigma benefits are to go straight to the bottom line. According to Breyfogel, Cupello, and Meadows (2001), "Some people view Six Sigma quality as merely a rigorous application of basic and advanced statistical tools throughout an organization. There are a number of Six Sigma consultants and training organizations that have simply repackaged the statistical components of their previous TQM programs and renamed the Six Sigma. Others view Six Sigma as merely a sophisticated version of Total Quality Management (TQM). They see it as an advanced form of TQM in which various continuous improvement system must be in place with a small amount of statistical analyses added in for good measure" (p.5).

Six Sigma emphasizes an intelligent blending with proven statistical tools to improve both the efficiency and effectiveness about customer needs. Six Sigma goals are not just improvements. Six Sigma focuses on economic wealth for both the customer' needs and owners' demands.

Taiichi Ohno developed the Toyota Production System (TPS) at the Toyota Motor Corporation after World War II (Imai, 1997). This production system's foundation is laid upon a foundation of Total Quality Management and Production Smoothing with an emphasis on Just In Time and Jidoka. TQM is a system for integrating quality maintenance, development, and improvement of all organizational levels to enable production and service at economical levels for customer satisfaction (Stonebraker & Leong, 1994)

TPS is also based on production smoothing. This approach is based on the term heijunka, or leveling production and batch quantities over time. This technique enables them to adhere to customer demands while keeping labor costs, set ups, inventories, and lead-time to a minimum.

One of the pillars that TPS stands on is the concept of Jidoka. This method gives machines or workers the ability to stop production as soon as a defect occurs.

Another pillar of the TPS is related to the Just In Time (JIT) principles. JIT is based on the principles of producing what is needed, when it is needed, in just the right quantity. In addition, it has four main areas of focus, which are the elimination of waste, respect for the people, continuous improvement, and focus on the customer (Stonebraker & Leong 1994).

All inputs associated with JIT relate to the pull manufacturing system. One of the main ingredients in a pull system is the Kanban. A Kanban is used to let upstream processes know that more of a particular part is needed. When a container is emptied, the card is delivered upstream and is the signal for that process to build the quantity identified on the card (Northey & Southway, 1993). This contrasts to normal push production systems used in many manufacturing plants.

Usually, schedules are created in advance based on a forecast to generate production (Imai 1997). The main difference between push and pull systems is that pull systems are driven by actual demand. As the world started to take notice of the robust manufacturing systems that were created by Toyota, changes began to take place. It was realized that the mass production systems created by Henry Ford in the early 1900's could not compete against demand driven systems. From this realization came the concept of TPS and JIT.

Background of Lean Manufacturing

According to Jones, Jim, and Womack (2002), "after World War II, Eiji Toyoda and Taiichi Ohno at the Toyota Motor Company in Japan pioneered the concept of Lean production" (p.11). Toyota Motor Company developed their original moving assembly line called 'Toyota Production System (TPS)' to keep material flow continuously. The TPS was developed and promoted by Toyota Motor Corporation and is being adopted by many Japanese companies in the aftermath of the 1973 oil shock. According to Monden (1983), "Though the main purpose of the system is to reduce costs, the system also helps increase the turnover ratio of capital and improve the total production of a company as a whole" (p.1).

The Toyota family originally owned a big textile company in Japan. After World War II, the Toyota family decided to start new venture from Toyota Automatic Loom

Company to a Toyota Motor Company. According Wren and Greenwood (1998), "the Toyota Automatic Loom works was the product of the inventive and entrepreneurial genius of Sakichi who perfected Japan's first power driven loom and held numerous patent for automatic looms and textile product"(p.218). Sakichi sold his automatic loom patents to finance a research of automobile manufacturing system with his son Kiichiro. In the mean time, General Motors and Ford assembly plants had relocated in Japan. Therefore, challenging the new automotive venture for the Toyota Group was considered a risky business. According to Wren and greenwood (1998), the eldest son of Sakichi, Kichiro Toyota, was in charge of loom production. He had a great interest of the automotive engine as well. He had studied Western automotive industry to modify their management into Toyota's way of automobile assembly line. Even though conditions make competitive automobile products against Western countries, Kiichiro was trying to modify higher production quantities into smaller production quantities in order to match with Japanese economy size at that time. In addition to the smaller production quantities, Kiichiro was trying to establish Toyota cars as fuel-efficient vehicle that would match Japanese narrow streets and tight expenditure of Japanese people (Wren & greenwood, 1998). As Jordon and Michel (2001) state, "Toyota and Japan needed a different manufacturing paradigm" (p.14).

According to Jordan and Michel (2001), "Toyota and Ohno realized they had to get the most out of each worker, and that would happen only if the workers knew how to do many different tasks effectively"(p.14). After World War II, when Japanese manufacturing industry was suffering from a poor quality production system, Toyota Motor Company started to develop their owns efficient production principal. According to Jordan and Michel (2001), "the Japanese government, with support from the United States occupation forces, provided a protective cover for struggling Japanese industries while the domestic manufactures tried to find the way" (p.14).

According Jones, Jim, and Womack (2002), "After World War I, Henry Ford and General Motors' Alfred Sloan moved world manufacturing from centuries of craft production led by European firms into the age of mass production. Largely as a result, the United States soon dominated the global economy"(p.11). Henry Ford knew that he could keep the prices of his products low by reducing the production cycle by using their assembly line. However, in the book, "Becoming Lean", Liker (1997), said that Ford made a dramatic wrong turn at his new Rouge complex. He maintained the assembly track but rearranged his fabrication machinery into process villages. He proceeded to run a push schedule in which growing fluctuations in end customer demand and persistent hiccups in upstream production were buffered by a vast bank of finished units forced on the dealer network and equally vast buffers of parts at every stage of production upstream from assembly. Thus 'Flow' production, as Ford term it in 1914, became 'Mass' production and the opportunity to carry lean thinking to its logical conclusion was lost (p. xiv)

The focus on the Ford flow production system was to get their automobiles out and keep it moving fast, and furnish mass production as soon as possible. Ford did not consider inventory for next processing. Thus, they had too many inventory and raised cost in processing. Finally, Ford did not upgrade efficient product system from the old original process.

Also, Lean Enterprise and Lean Manufacturing are the current trends in western manufacturing operations. The Lean Enterprise is based on five basic principles, which are used to define value from the customer perspective, identify the value stream, optimize flow, pull from the customer, and drive toward perfection (Womack & Jones, 1991).

This method achieves the above objective of location and eliminating waste from all operations. Although waste can be found in many places, its roots can be traced to seven separate forms, which are mistakes requiring fixing, unnecessary production, inventory, unnecessary processing, unnecessary movement and transport waiting, and product that don't meet the customer's requirements (Womack & Jones 1991).

A tool that be used in an attempt to change from the traditional mass production style to more of a lean processing style is the value stream map, which is a diagram that defines each step of the material and information flow needed from initial order to delivery. Value stream mapping is used to identify sources of waste and eliminate them to add value to the process (Rother & Shook, 1999). The first step is to walk the valued stream from shipping, where the customer pulls product from, to the initial upstream process. From the information gathered on this value stream walk, a current state map of the process is created. After it is known what the current situation is, a future state map is drawn to show how the process should look (Connor, 2001). In order to achieve the future state, a work plan is created that lists action items necessary to change from the current state. These changes can take several months to several years before the future state is achieved (Connor, 2001).

Definition & Function of Six Sigma and Lean Manufacturing

Six Sigma is a team-based approach to problem solving and process improvement. According to Breyfogel (2001), some people think Six Sigma is a strong application of statistical tools. However, other people think Six Sigma is a just sophisticated part of Total Quality Management.

Some organizers have Six Sigma roles and give some titles to people who work in Six Sigma. The names are Owner, Champion, Master Black Belt, and Green Belt (Breyfogel, 2001).

In Six Sigma, the champion is full-time managerial-level personnel responsible for coordination and overseeing Lean Six Sigma implementation, champions are direct reports to either the CEO (or other "C" level person) or a unit P & L manager / president (Michael L. George, 2002. p102)

The Master Black Belt serves as a coach and mentor or consultant to black belts working on a variety of project. The master black belt may also become a part-time Six Sigma trainer for Black belt and other groups. Finally the master black belts may get involved in special Six Sigma related projects. (Pande and Holpp 2002)

The black belt is the full time person dedicated to the Six Sigma process. The black belt leads, inspires, manages delegates, coaches, and becomes an expert in tools for assessing problems and fixing of designing process and products. The black belt works as a member of a team assigned to a Six Sigma project and is responsible for organizing the team, participating in training, and keeping projects moving to completion. (Pande and Holpp 2002)

The Green Belt is someone trained in Six Sigma Skills; however, Six Sigma is an additional duty for the Green Belt. The role of the green belt is to bring the new concepts and tools of Six Sigma right to the day-to-day activities of the business. (Pande and Holpp 2002)

Clifford Fiore (2005) states that the Lean definition is "Lean adj 1. Not fleshy or fat; thin. 2. Containing little or no fat. 3. a. Not productive or prosperous. b. Severely curtailed or reduced. Translating this definition of lean into the business world, lean means producing what is needed, when it is needed, with the minimum amount of materials, equipment, labor, and space. In other words, producing what is required and when it is required, but with minimal investment" (p.11)

Overview of the Six Sigma & Lean Manufacturing

Six Sigma can be carried out with the various approaches. The most important approach is to Define, Measure, Analyze, Improve and Control (DMAIC). Each step in the cyclical DMAIC process is required to ensure the best possible results. It is a data driven quality strategy for improving processes.

Define refer to the customer, issues that are critical to quality, and business process involved in defining boundaries: the stop and start of the process. Measure is the performance of the Core Business Process, such as developing a data collection plan for the process. Analyze is the data collected and process map to determine root causes of defects and opportunities for improvement, such as prioritizing opportunities to improve. Improve is the target process by designing creative solutions to fix and prevent problems such as developing and deploying implementation plan. Control is the improvements to keep the process on the new course such as requiring the development, documentation and implementation of an ongoing monitoring plan.

Six Sigma is a high technology and high performance based. Six Sigma can reduce 3.4 defects per one million opportunities. But in comparison, Three Sigma accepts about 67,000 defects per million opportunities. Achieving Six Sigma high level of performance requires a strong commitment to improvement. It is possible in any business, not only in manufacturing, but electronics as well.

In Lean Manufacturing, Clifford Fiore (2005) refer to the flow concept as, "flow in the business world refers to the continuous movement of products and information through a value stream. Relating this to the objective for a lean enterprise, the goal here is to minimize idle time, which really equates to inefficiency and waste" (p.13)

Summary

Six Sigma and Lean Manufacturing are today's powerful business strategies but are still widely misunderstood in their approach to performance improvement and organizational transformation. Six Sigma and Lean Manufacturing are at an entirely new strategic level. Also, they are one-two punch for companies' strategy. They will provide business leaders with both a strategy for competition in the future of business and a strong set of excellent business best practices.

Chapter III: Methodology

Introduction

This study will revolve around the relationship between Six Sigma and Lean Manufacturing. The approach for this study was qualitative and provided an in depth scrutiny of the process situation, events, and behavior.

In 1980, companies were asked by their customer to improve quality and speed. Lean Manufacturing and Six Sigma appeared as a solution to quality and speed. Lean started by maximizing speed in manufacturing but Six Sigma started by zero defects. The decades-old manufacturing theory is changing as it's applied to business process strategies. Six Sigma is a highly disciplined and project based methodology that can help companies focus on developing and delivering near perfect product and services. Six Sigma concepts are proactive tactics based on the idea for zero defects. Usually Six Sigma and lean manufacturing fight each other because Lean Manufacturing supporters indicated about Six Sigma's slow speed, but Six Sigma supports indicated demerit of Lean Manufacturing about customer demand and defective quality. This report will now explain integration and harmony in both tools. First the report will explain the similarities of both Six Sigma and Lean Manufacturing. Next, it will explain the differences of both tools.

Similarities about Six Sigma and Lean Manufacturing

The Lean Manufacturing and the Six Sigma appeared by customer demand, saving cost, and time. First, both tools need a team, such as Six Sigma's project teams or Kaizen teams. Second, the team needs specialist such as master belts or black belts, or lean consulting specialist. Third, they change organization such as behavior change or system change in organization to improve and to be effective. Last but not least, both tools show the possibilities to achieve improvement in cost, quality, and time. Therefore, Lean Manufacturing and Six Sigma may be successful in producing tools that both customer and companies demand.

Differences between Six Sigma and Lean Manufacturing

In main difference between the two theories is that Six Sigma started on reducing variation, improving process results, and zero defects. However, Lean Manufacturing focused on eliminating waste and improving flow in manufacturing. Therefore, Six Sigma eliminated defects, but does not explain the problems of how to improve process flow and also Lean Manufacturing does not explain statistical tools to prove the results that Six Sigma used to achieve the process. About this, this report shows the more detailed.

Six Sigma focused on improving process capability, eliminating variation, and zero defects. Cliford Fiore (2005) states that, "Six Sigma focused heavily on variation reduction through statistical analysis for factory related issues. Additional goals of Six Sigma included rework/scrap elimination and process characterization and control."(P. 7) Also according to Cliford Fiore (2005), "the Key objectives of Design for Six Sigma are to predict the quality level of new product designs, design quality into new products, and improve the quality of existing products."(p. 167). In their approach, Six Sigma depends on many factors such as a company's culture, and commitment.

The approach for this field problem was qualitative and the study provided an in depth scrutiny of the program situations, events, employee interactions, and observed behavior.

Six Sigma's initiatives can be carried out in various stages and various steps. One such approach is to Define, Measure, Analyze, Improve, and Control (DMAIC). It is a data driven quality strategy for improving process and forms an integral part of the company's Six Sigma quality initiative. Each step in the DMAIC process in required ensuring the best possible results. In these stages, Define means to define the project goals and customer needs. Measure is to measure the process to determine current performance. To measure, it pours in all possible input variables and narrows the possibilities by using statistical tools such as Pareto Charts. Analyze is to analyze and determine the root cause of the defects. To Analyze, Six Sigma use quantitative analysis to further narrow the field using tools such as correlation and hypothesis study. Improve is to improve the process by eliminating defects. To improve, it implements and validates solutions using tools such as ANOVA. Control means to control future process performance. To control, it implemented system to ensure improvements are maintained SPC or Control plans.

Lean Manufacturing focuses on improving flow and eliminating waste. Lean Manufacturing supports exactly what they want. Cliford Fiore (2005) states, "The Lean Manufacturing initiative is focused on waste elimination and reducing cycle time in the factory. It embraced the concepts of single-piece flow, understanding true customer value, and eliminating non-value added tasks." (P.7)

Lean Manufacturing started from industrial engineering. So the Lean Manufacturing application is different by the number of tools such as values stream mapping. Cliford Fiore (2005) states, "Essentially, the goal of a company adopting the Lean philosophy is to make each process as efficient and effective as possible, and then to connect those processes in a stream or continuous chain that is focused on flow and maximizing customer value." (P. 11)

Regarding the approach of Lean Manufacturing, its most important qualities are Value Stream Mapping (VSM), single piece flow, and kanban system. First, Value Stream Mapping is a visual technique for describing how a business currently operates. Cliford Fiore (2005) states, "In a lean business enterprise, a value stream is simply the connection of process steps with the goal of maximizing customer value. But more specifically, a value stream represents the linkage of all value added and non value added activities associated with the creation of a product or service desired by a customer." (P. 23)

A Value Stream Mapping is divided into two sections--the flow of information and the flow of material. Value Stream Mapping is a simple, yet powerful tool that anyone can employ. Generating current and future value stream maps and combining them with a detailed plan to transition from one to the other is an ideal way to begin your company's lean transformation. Most important Value Stream Mapping can easily and powerfully make outline and distinguish the value of a product. Value Stream Mapping can eliminate many costly errors by understanding the proper process of product. Value Stream Mapping is a map that outlines the current and future a production system such as the 'Big picture.' Therefore, Value Stream Mapping allows users to understand where they are and what wasteful acts need to be eliminated. The user can then apply Lean Manufacturing principals to transition into the future state. Because Value Stream

Mapping is a pencil and paper tool, users can easily see and understand the flow of material and information when products make their way through the value stream.

The Value Stream Mapping can divide two parties, such as the value-adding and non-value-adding activities, that are required to bring a product from raw material through delivery to the customer. In other words, Value Stream Mapping is an outline of a product's manufacturing life cycle that identifies each step throughout the production process. The Value Stream Mapping is a big-picture tool that takes into consideration all processes and seeks to improve the enterprise as a whole. The overall goal of Value Stream Mapping is to move from batch and push to one piece flow (Single Piece Flow) and pull (Kanban System) through the entire value stream. Therefore, its ultimate goal is to optimize the flow of the entire system by design and introduce a lean value stream.

Single Piece Flow is used to help manufacturing flow and supply chain as single unit. Usually, manufacturing has lots of batches of parts and simultaneous processes for transferring and shipping or more. But Single Piece Flow uses one by one. So Single Piece Flow supports Just In Time, Lean Manufacturing, and many others. Single Piece Flow records batch sizes for historical system. Then, it calculates optimum batch sizes and transferred sizes. Therefore, Single Piece Flow is a similarity of the pull system by one line flow. For example, Clifford Fiore (2005) state, "The customer creates the pull, or need, that directly drives the activities of the process to satisfy the need. A pull system is defined as the following; a pull system completes a quantity of work that is directly linked to customer demand. Materials are staged at the point of consumption. As materials are consumed, signals are sent to previous steps in the process to pull forward sufficient materials to replenish only those that have been consumed"(p.18).

Kanban means visible record. In other words, that is a card signal or communication in manufacturing process, such as what in parts, when to start, when to stop, how many need, where to deliver and so on. "Kanban is often seen as a central element of lean manufacturing and sis probably the most widely used type of Pull signaling system. Kanban was derived from the Japanese language and mean card signal"(Lean Manufacturing Resource Guide, Dec, 05, 2005).

Kanban is on a pull system to schedule production without intervention or waiting. Kanban uses some analysis of manufacturing processes, such as Single Card, Double Card, or Kanban Working. So Kanban considers that inventory as waste, evil, or expensive problems. Kanban tends to reduce inventory from initial level to minimum level.

Lean Manufacturing's specific approach is Five S, namely Sort, Store, Shine, Standardize, and Sustain. Five S means five initial terms starting with S. These initial terms are to create a workplace for visual control and lean production. Clifford Fiore states (2005) that, "Five S (5s) is a methodology to transform and maintain a work environment that supports lean implementation. In addition, it is a methodology that promotes a culture of order and efficiency in the workplace. The term five S is derived from five Japanese words (in parentheses below) representing the elements that drive the transformation in the workplace."(p.22.). Also Clifford Fiore (2005) states about the 5S definition that, "Sort means to clearly separate necessary items from the unnecessary. It requires the identification of what is needed to perform a particular operation or task and the removal of unneeded tools, equipment, files, parts, furniture, and so on, from the work area. Store means to neatly arrange and create a place for each item for ease of use. It requires items to be organized based on the frequency of use. In addition, visual aids are employed to easily identify the needed items. Shine means to perform daily cleaning and inspection of the equipment and work area. Standardize means to determine, share, and use the best processes and methods. Standardization serves to minimize the variation and becomes the baseline for further improvement. Sustain means to maintain the gains and to create a culture for future improvement. This element supports the philosophy of continuous improvement"(p.23). But some books or articles use simplify and scrub instead of store and shine. Therefore, even though the terms are different, the terms support the base to create discipline in the workplace. Namely, 5 S are the logical process steps in a workplace especially in Lean Manufacturing.

Benefit of synergy effect of Six Sigma and Lean Manufacturing

In this report, Six Sigma and Lean Manufacturing have some similarities and differences. From their similarities and differences, Six Sigma and Lean Manufacturing can be integrated and improved.

The Lean Manufacturing and Six Sigma methodology make a synergy effect to provide results. The effect results are more significant than the results of individual approaches.

First, the Six Sigma processes are changed from slow to fast by Lean Manufacturing. Also Lean Manufacturing helps identify the highest impact by Six Sigma. Last, Six Sigma and Lean Manufacturing provide the structure easily for optimum flow.

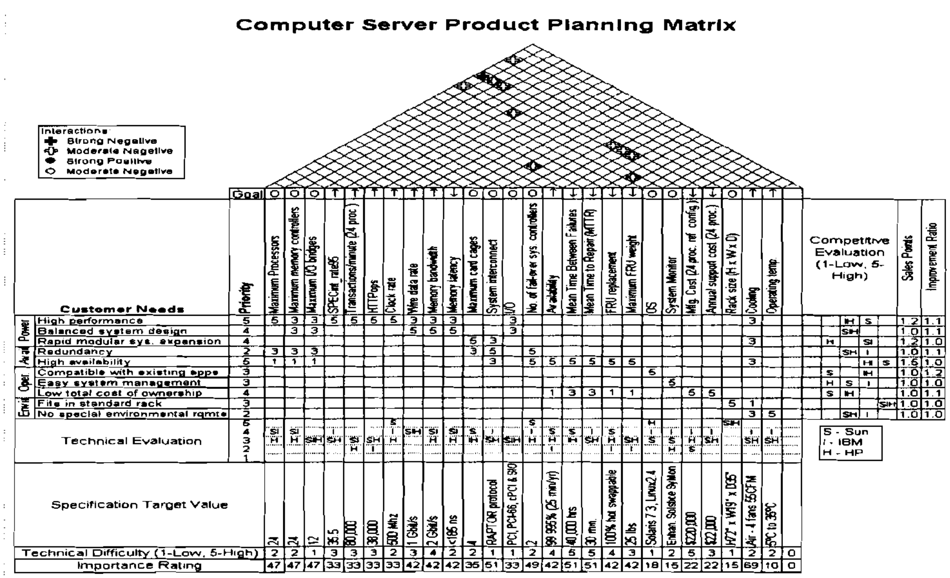
Six Sigma and Lean Manufacturing are more detailed and showed by methodologies, which are DMAIC and Lean Manufacturing steps.

Define

The define phase is important and the first steps in Six Sigma and Lean Manufacturing. In this phase, Six Sigma and Lean Manufacturing recognize the problem in non-valued process. Also both methodologies take customer demands into consideration. In this phase, the important tools are Voice of the customer from Six Sigma and Value Stream Mapping from Lean Manufacturing. Therefore, this phase decides to create value and begins to focus on a particular non-valued process.

In Define phase tools, the Voice of the Customer tool is important to Define phase involved in the business parties for a customer. Gary Conner (2002) states that, "the Voice of the Customer (VOC) tool is important to all parties involved in the marketing, sales, manufacture, distribution, and service of materials to the customer. In other words, everyone in the organization should understand what the customer expects"(p.78). For this Voice of Customer purpose, an example is shown below in Figure 3. 1.

Figure 3. 1: Computer Server Product Planning Matrix

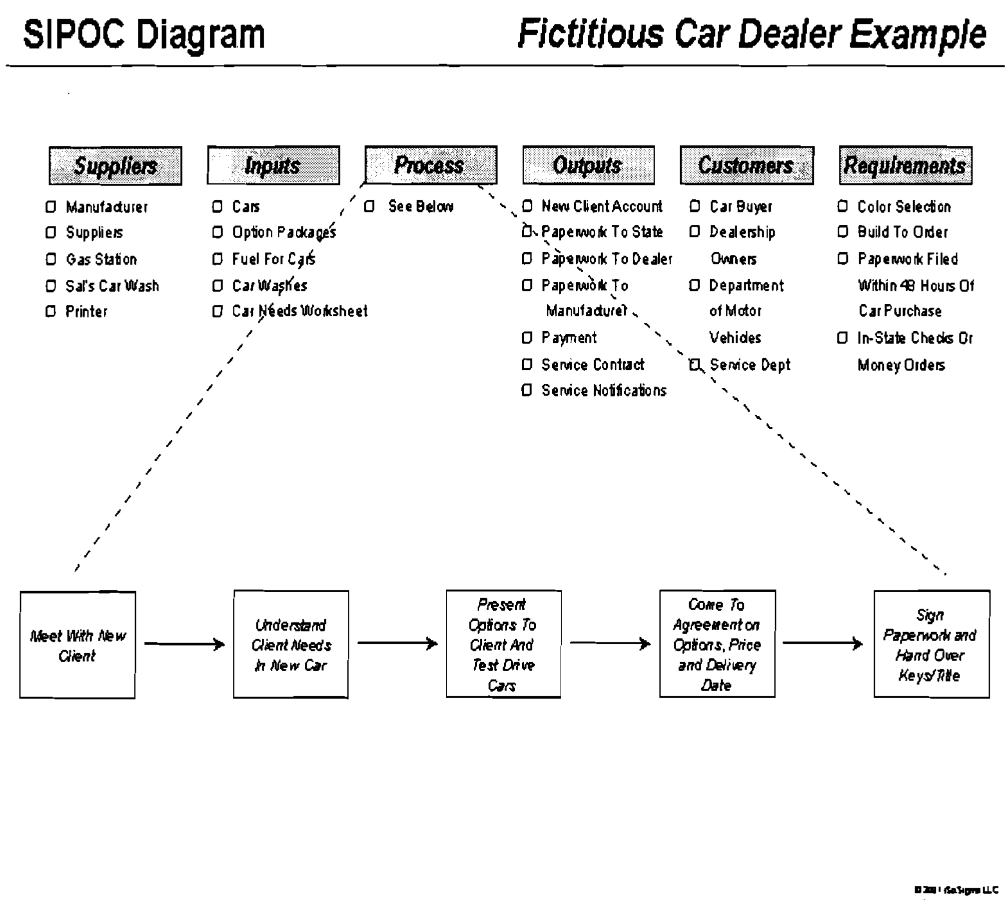


www.npd-solutions.com/serverppm.gif

SIPOC is a flow chart technique. This is a qualitative analytical tool. Pyzdek

(2003) states that, “The SIPOC shows the linkage between Suppliers, Input, Process activities, Output, and customers (SIPOC). SIPOC is a flow charting technique that helps identify those processes that have the greatest impact on customer satisfaction”(p.67). For this SIPOC, an example is shown below in Figure 3. 2.

Figure 3. 2: SIPOC Diagram of Fictitious Car Dealer Example



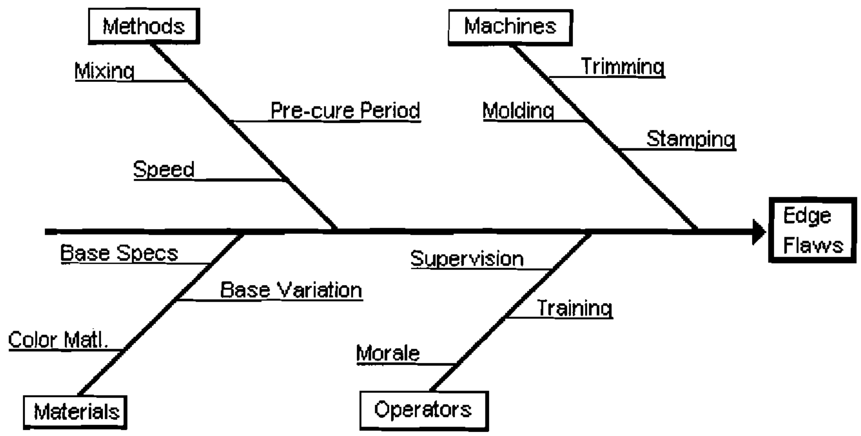
http://www.isixsigma.com/library/graphics/SIPOC.gif

Measure

In this phase, both methodologies gather quantitative and qualitative data to review a clear current situation. After gathering information, the organization is prepared to change to eliminate wasting processes and problems. For this phase, both methodologies understand the process and various data. In this phase, Six Sigma use cause and effect matrix and measurement system analysis. Also, Lean Manufacturing still uses Value Stream Mapping with cycle time and identification of waste.

In tools of measure, Cause and Effect tools explain to relation of between customer and supplier. Pyzdek (2003) said that, "the six sigma philosophy focuses the attention of everyone on the stakeholders for whom the enterprise exists. It is a cause and effect mentality. Well-designed management systems and business processes operated by happy employees cause customers and owners to be satisfied or delighted. Of course, none of this is new. Most leaders of traditional organizations honestly believe that this is what they already do. What distinguishes the traditional approach form Six Sigma is the degree of rigor"(p.8). For this Cause and Effect purpose, an example is shown below in Figure 3. 3.

Figure 3.3 : Cause and Effect Diagram for Edge Flaws



Cause and Effect Diagram for Edge Flaws

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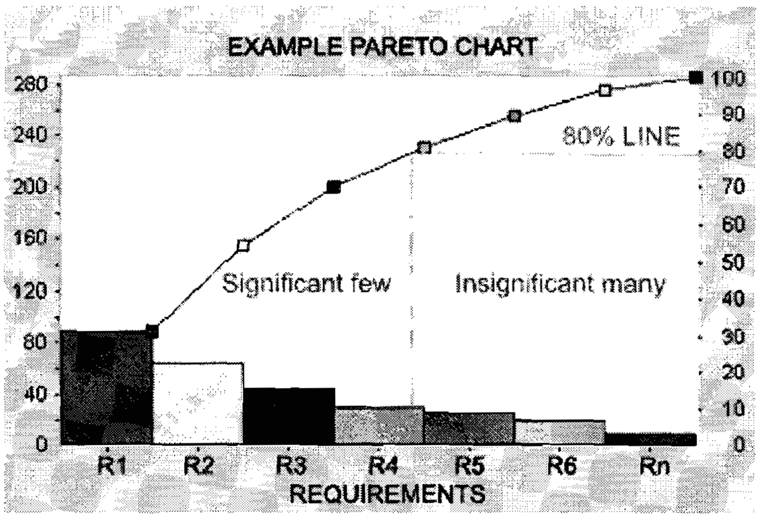
The Pareto Chart, which most companies use, focuses on the high level parties. Andrew Berger (2003) states that, "Pareto Charts used to graphically represent the relative impact of events (sales of different products, defect types, etc) on some predetermined outcome (profitability, total number of defects, etc). They are often used to assist in identifying the most appropriate starting position for a project. A Pareto Chart is constructed by collecting the data that qualifies the impact of each event on the out come of interest. The events are then arranged in tabular form in order of highest impact to lowest (x-axis). If using a percentage chart, calculate the percentage of total value of each of the events and arrange them in order of decreasing value (x-axis). The y-axis represents either the range of values or the range 0-100% or both"(p.222). For this Pareto Chart purpose, an example is shown below in Figure 3. 4.

Figure 3. 4 : Example Pareto Chart



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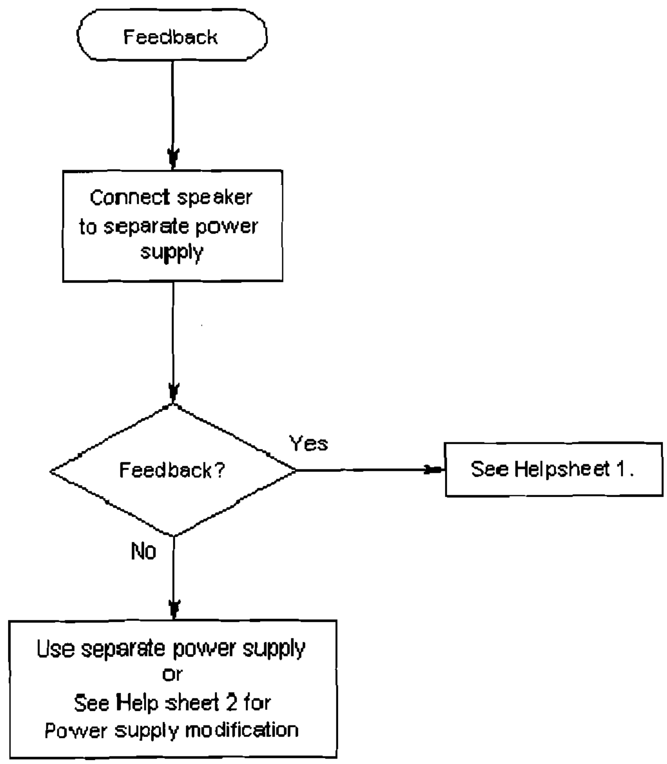
The Flow Chart shows the path of steps of work, namely, and the Process flow chart. Forrest W. Breyfogel III, James M. Cupello and Beck Meadows (2001) said that, "creating process Flow Charts as a team is a great way to display an accurate picture of the process and to gain insight into opportunities for improvement. Later in the project, the flow chart ca be used for maintaining consistency of process application and subsequent improvement /establishment of standard operation procedures"(p.158). For this Flow Chart purpose, an example is shown below in Figure 3.5.

Figure 3. 5 : Flow Chart of Academic Integrity Process



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Failure Mode and Effects Analysis is an advanced analytical tool. This is used to identify potential failures in a process, product, or service. Gary Conner (2002) states that, "Failure Mode and Effect Analysis (FMEA) is a potential tool for focusing team activities on critical inputs and variables in the process under study. It helps establish priorities and can help a team avoid spending time collecting data on a non-critical aspect of the process. It also draws attention to the interrelationships between inputs and variables.

Most importantly, it assigns a level of risk to each variable"(p.145). For this FMEA purpose, an example is shown below in Table 3. 1.

Table 3. 1 : FMEA Template

Failure Modes and Effects Analysis (FMEA) Template[2]

<table>
<tr><td colspan="3">Project No;</td><td colspan="2">Component:</td><td colspan="2">Page:</td></tr>
<tr><td colspan="5" rowspan="2">Component Description:</td><td colspan="2">Date:</td></tr>
<tr><td colspan="2">Drg No:</td></tr>
<tr><td colspan="2">Team Leader:</td><td colspan="3">Team Members:</td><td>Minutes by:</td><td>Pages:</td></tr>
<tr><td rowspan="2">No</td><td rowspan="2">Failure Mode</td><td rowspan="2">Detection Method</td><td colspan="2">Equipment Affected</td><td rowspan="2">Safety Systems Response</td><td rowspan="2">Comments</td></tr>
<tr><td>Identification</td><td>Effects</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

2 Adapted from ICI Australia Engineering Hazard Study Course Notes

http://www.mishc.uq.edu.au/NMIRAG/images/Templates_FMEA.gif

Analyze

In this phase, Six Sigma needs various analytical technologies to get causes about variables. Analyze phase is usually the primary concern of Six Sigma. Six Sigma uses various analytical and statistical techniques for analyzing. But Lean Manufacturing does not use various analytical and statistical techniques like Six Sigma. Lean Manufacturing focuses mainly on eliminating waste. Therefore, if Six Sigma techniques integrated Lean Manufacturing process, the synergy effect will be a more powerful tool. For this phase, Six Sigma needs FMEA and various skills. Also, Lean Manufacturing needs Value Stream Mapping that focuses on time saving and process efficiency.

In Analyze phase, ANOVA is important to Six Sigma and is a statistical test of significance in the differences between samples. Pyzdek (2003) said that, "Analysis of Variance (ANOVA) is a technique which subdivides the total variation of a set of data into meaningful component parts associated with specific sources of variation for the purpose of testing some hypothesis on the parameters of the model or estimating variance components"(p.724). For this Analysis of Variance purpose, an example is shown in below in Figure 3. 6.

Figure 3. 6 : One-Way ANOVA of Summary Statistics

[11/29/01 16:21 "/ANOVA1" (2452242)]
One-Way ANOVA

Summary Statistics

Dataset	Mean	SD	SE	N
ANOVA1_Class1	78.839159	8.47365071	0.423682536	20
ANOVA1_Class2	84.158244	7.72746609	0.386373304	20

Null Hypothesis: The means of all selected datasets are e
Alternative Hypothesis:The means of one or more selected datase

ANOVA

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
Model	1	282.926652	282.926652	4.30253	0.04488
Error	38	2498.81328	65.7582443		

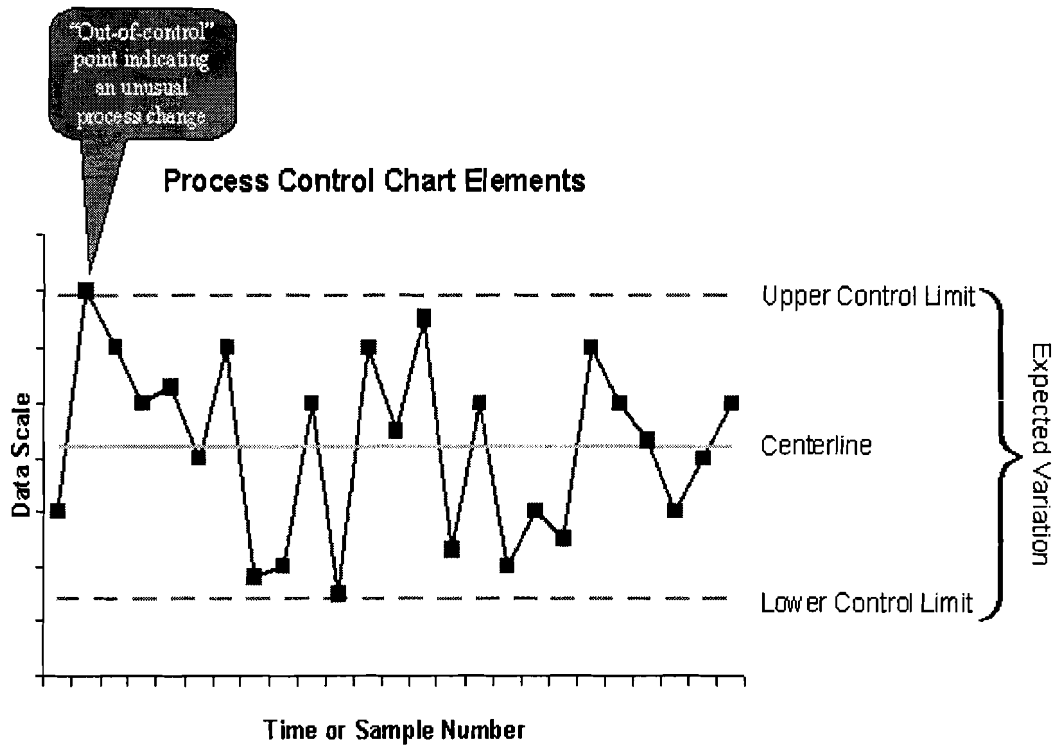
At the 0.05 level,
the population means are significantly different.

http://www.originlab.com/www/products/images/one_way_anova_results2.gif

The Control Chart is a chart with upper and lower control limits. This is used to detect trends toward either control limit. Pyzdek (2003) states that, "In statistical process control (SPC), the mean, range, and standard deviation are the statistics most often used for analyzing measurement data. Control charts are used to monitor these statistics. An out of control point for any of these statistics is an indication that a special cause of variation is present and that an immediate investigation should be made to identify the special cause"(p.393). For this Control Chart purpose, an example is shown below in

Figure 3. 7.

Figure 3.7 : Process Control Chart Elements



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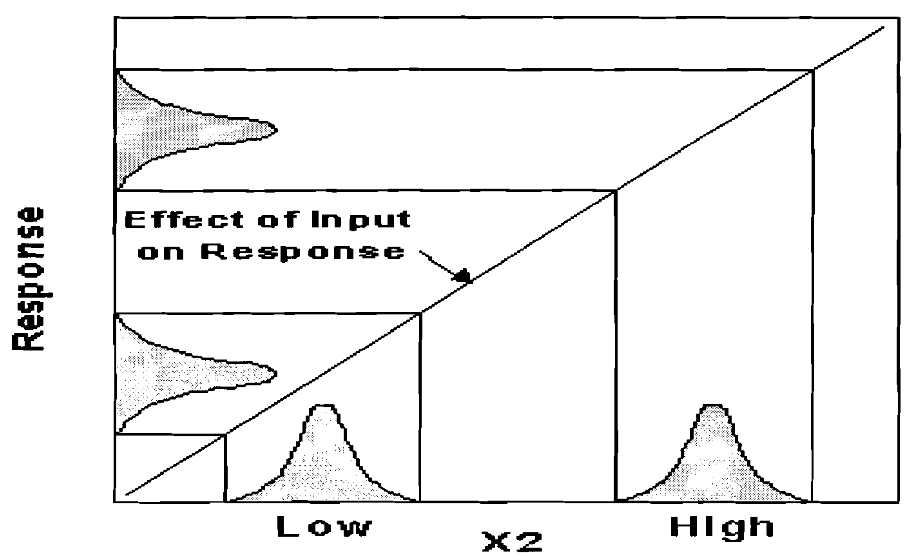
Improvement

In this phase, Six Sigma and Lean manufacturing gather information and decide on a specific solution about various defects and waste from the analyze phase. Then the solution is implemented. Therefore, the implemented solution helps to ensure prediction about elimination defects and waste. For this phase, the Six Sigma uses DOE and Lean

Manufacturing needs Kaizen.

Design of Experiments (DOE) plays an important role in quality improvement. This usually involves various variables. Gary Conner (2002) states that, "Design of Experiments (DOE) is an approach for exploring the cause and effect relationships between at least two variables. Through proper design, record keeping, and testing, interrelationships can be examined, priorities between variables can be established, and risk or loss can be accurately predicted from changes in essential process variables"(p.135). For this Design of Experiment purpose, an example is shown below in Figure 3. 8.

Figure 3. 8 : Reducing Variability with DOE



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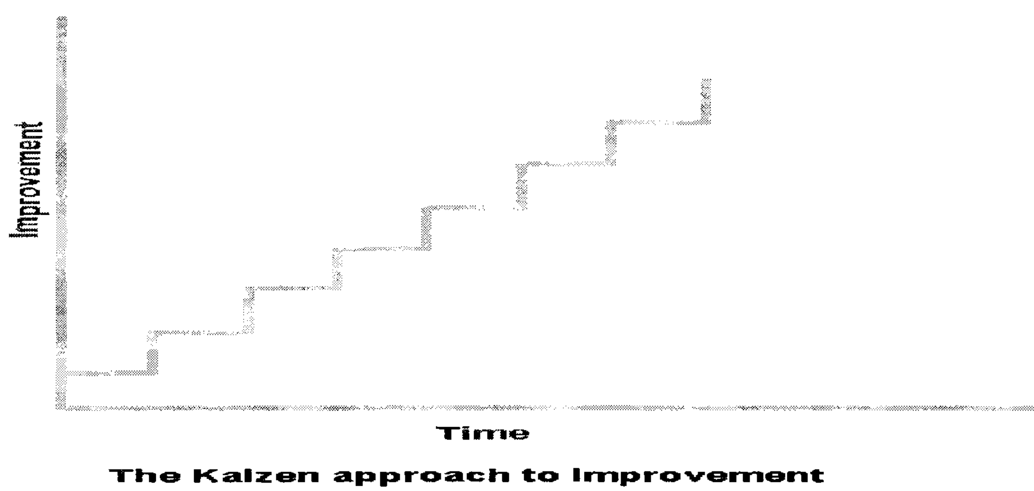
Kaizen is based on the Japanese language, namely, Kai, that means the alter or change. Also, Zen, which means good. Therefore, Kaizen means to be all continuous improvement. Gary Conner (2002) states that, "Kaizen- the term and the process- is all about making things better. Literally meaning continual, incremental improvement, this technique can be use to improve everything from work order entry to set up reduction, from engineering processes to packing and shipping practices. Kaizen can be further defined as a set of team based problem-solving practices that support the major systems of Total Quality Management (TQM), Just In Time (JIT), Total Product Maintenance (TPM), policy deployment, suggestion systems, and Value Stream Activities"(p.146). For this Kaizen purpose, an example is shown below in Figure 3. 9.

Figure 3. 9 : The Kaizen approach to improvement



http://staff.rit.tafensw.edu.au/mfinemore/Quality%20Management/Images_QM /kaizen.gif

Control

This phase goal sustains the improvements implemented. Firstly, this phase is used to control plan because the control checks continuously and reports variation when some variation is out of control. For this phase, Six Sigma uses statistical process control. Lean Manufacturing on the other hand needs 5 S because the 5 S helps keep value added efficiency and minimal waste.

In Control phase, the most important tool is 5 S. Lean Manufacturing's specific approach is 5 S, namely Sort, Store, Shine, Standardize, and Sustain. 5 S means five initial terms starting with S. These initial terms are to create a workplace for visual control and lean production. Clifford Fiore (2005) states that, "Five S (5s) is a methodology to transform and maintain a work environment that supports lean implementation. In addition, it is a methodology that promotes a culture of order and efficiency in the workplace"(p.22). For this 5 S purpose, an example is shown below in Figure 3. 10.

Figure 3. 10 : Quality Systems and Process Training

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Like all of above, Lean Manufacturing is stronger in some steps such as principles, flow, and control, than Six Sigma is. However, Six Sigma is stronger in some phases such as measurement, analyze, and improvement with statistical skills, than Lean Manufacturing is. Therefore, whole DMAIC with Lean Manufacturing integrated tools must strengthen both methodologies' goals.

Finally, the purpose of this study is to submit the synergy effect from Six Sigma and Lean Manufacturing from the results. The objective is to reduce the number of touches and the lead-time associated with the product process from Six Sigma and to concentrate on using Value Stream Mapping as a tool to reduce manufacturing lead times from Lean Manufacturing.

Limitations

This Study does not depend on specific data or figures. All of data of figures help to easily understand this study and theory related in this study.

Chapter IV: Summary and Results

Introduction

This chapter shows the summary and conclusion drawn from all the information gathered in the previous three chapters.

This section addresses several elements and includes a restatement of the problems and a review of the methods and procedures used to gather all the information found in this research.

The purpose of this study was to identify the synergy effect between Six Sigma and Lean Manufacturing from both DMAIC and Lean Flow. This study focuses on the Synergy effect and the possibilities such as 'Synergy Effect between Six Sigma and Lean Manufacturing.'

Objectives of this study were to:

The Lean Manufacturing and Six Sigma methodology make a synergy effect to provide results. The effect results are more significant than the results of individual approaches.

First, the Six Sigma processes are changed from slow to fast by Lean Manufacturing.

Second, Lean Manufacturing helps identify the highest impact by Six Sigma.

Last, the structure is provided easily for optimum flow by Six Sigma and Lean Manufacturing.

Six Sigma and Lean Manufacturing are more detailed and showed by methodologies which are DMAIC and Lean Manufacturing steps.

Summary

Define

The define phase is important and the first steps in Six Sigma and Lean Manufacturing. In this phase, Six Sigma and Lean Manufacturing recognize the problem in non-valued process. Also, both methodologies take customer demands into consideration consider about customer demands. In this phase, the important tools are Voice of the customer from Six Sigma and Value Stream Mapping from Lean Manufacturing. Therefore, this phase decides to create value and begins to focus on a particular non-valued process.

Measure

In this phase, both methodologies gather quantitative and qualitative data to review a clear current situation. After gathering information, the organization is prepared to change to eliminate wasting processes and problems. For this phase, both methodologies understand the process and various data. In this phase, Six Sigma use cause and effect matrix and measurement system analysis. Also, Lean Manufacturing still uses Value Stream Mapping with cycle time and identification of waste.

Analyze

In this phase, Six Sigma needs various analytical technologies to get causes about variables. Analyze phase is usually the primary concern of Six Sigma. Six Sigma uses various analytical and statistical techniques for analyzing. But Lean Manufacturing does not use various analytical and statistical techniques like Six Sigma. Lean Manufacturing focuses mainly on eliminating waste. Therefore, if Six Sigma techniques integrated Lean Manufacturing process, the synergy effect will be a more powerful tool. For this phase, Six Sigma needs FMEA and various skills. Also, Lean Manufacturing needs Value Stream Mapping that focuses on time saving and process efficiency.

Improvement

In this phase, Six Sigma and Lean manufacturing gather information and decide on a specific solution about various defects and waste from the analyze phase. Then the solution is implemented. Therefore, the implemented solution helps to ensure prediction about elimination defects and waste. For this phase, the Six Sigma uses DOE and Lean Manufacturing needs Kaizen.

Control

This phase goal sustains the improvements implemented. Firstly, this phase is used to control plan because the control checks continuously and reports variation when some variation is out of control. For this phase, Six Sigma uses statistical process control. Lean Manufacturing on the other hand, needs 5 S because the 5 S helps keep value added efficiency and minimal waste.

Result

Based on the methods discussed previously, a new integrated model is developed as shown in Figure 3. 11 and Figure 3.12

Figure 3. 11 : Integrated Six Sigma and Lean Manufacturing

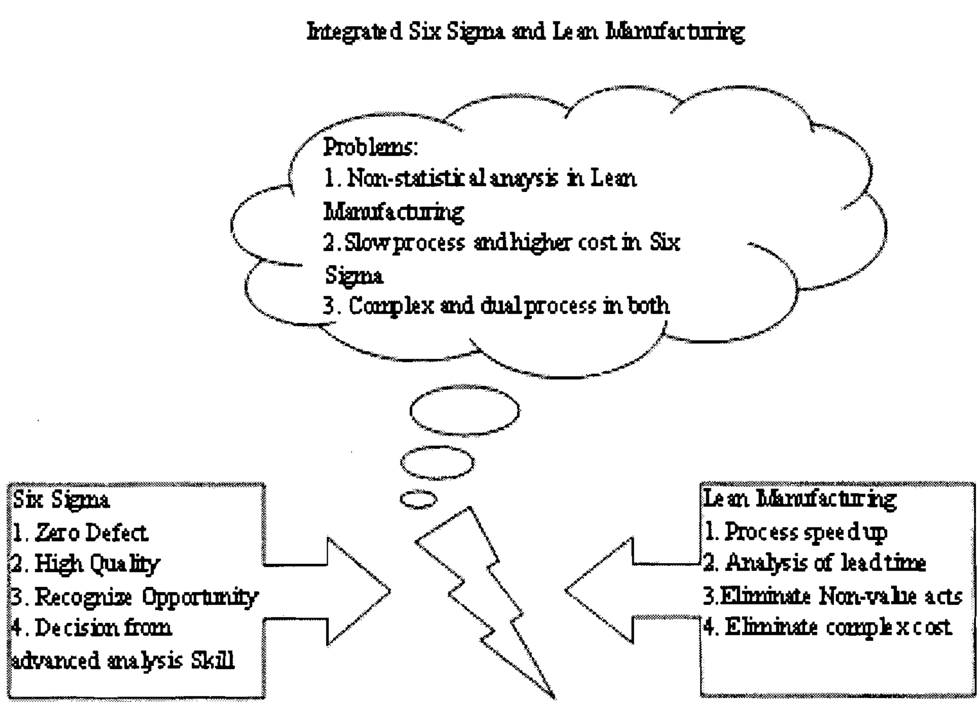
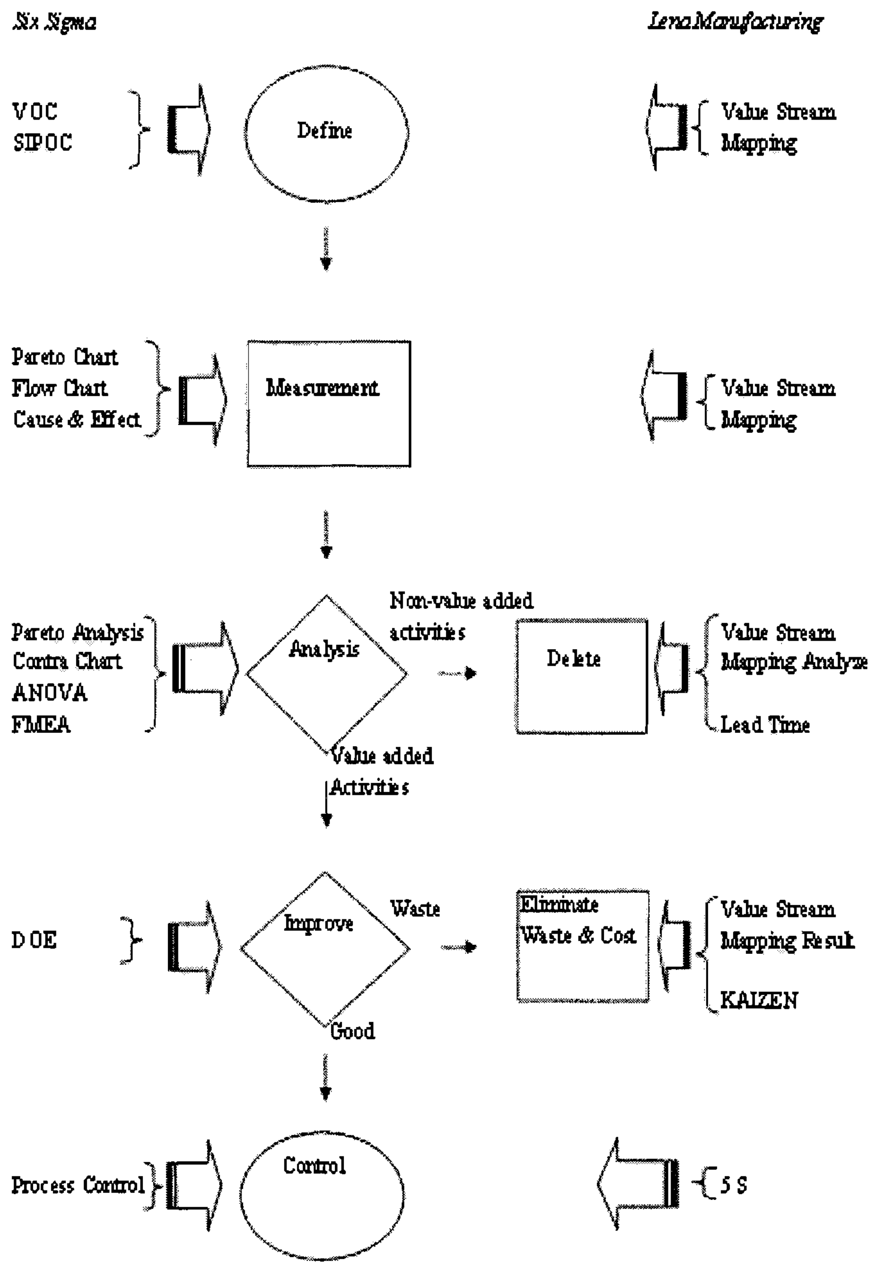


Figure 3. 12 : New Improved Integrated Model



This Lean Manufacturing and DMAIC of Six Sigma model is created with lean techniques. Kaizen is one of key improvement tools used by this model. This model also develops DMAIC based Lean Manufacturing methodology for waste elimination in the daily activities.

Define decides the scope and sets objectives in whole process. Measure is the current state process map such as process steps, process time, and lead times from the work place. Analyze is current state and separates value and non-value added processes, bottleneck constraint and process efficiency. Improve process by designing a future state map by eliminating waste. Control holds the gain with monitor results over time.

Like all of above, Lean manufacturing is stronger in some steps such as principles, flow, and control, than Six Sigma is. However, Six Sigma is stronger some phases, such as measurement, analysis, and improvement with statistical skills than Lean Manufacturing is. Therefore, whole DMAIC with Lean Manufacturing integrated tools must strengthen about both methodologies' goals.

Both Six Sigma and Lean Manufacturing each have some weakness such as arrangement of statistical problems, slow speed, higher implemented cost, and so on. Usually in DMAIC phases by Synergy effect between Six Sigma and Lean Manufacturing, Six Sigma focuses on Define, Measurement, Analysis phases. Also Lean

Manufacturing focuses on the Improve and Control phases. When Six Sigma joins in Lean Manufacturing, they take the synergy effect. From Six Sigma, they have a clear definition about process problems. Also, Six Sigma supports advanced statistical skill to solve the analytical problems. From Lean Manufacturing, they make the process help to simplify the process. Also they can take time saving and eliminate dual process cost or wastes. For example, in an Analysis phase, they can separate two parts about non-value added activities and value-added activities. Also, in an Improve phase, they can eliminate the non-required cost and wastes from VSM results.

Finally, the purpose of this study is to submit the synergy effect from Six Sigma and Lean Manufacturing from the results. The objective is to reduce the number of touches and the lead times associated with the product process from Six Sigma and to concentrate on using Value Stream Mapping as a tool to reduce manufacturing lead times from Lean manufacturing. Therefore, if Six Sigma and Lean Manufacturing work together, the synergy effect will increase and create much higher advantages in analyzing and manufacturing processes.

Chapter V: Discussion

The researcher of this study recommends that more emphasis be placed on the importance of Synergy effect between Six Sigma and Lean Manufacturing. Due to a lack of specific data from research and upper management knowledge about Six Sigma and Lean Manufacturing, constraints were placed on this report. Due to the huge amount of information available about Six Sigma and Lean Manufacturing tools and technologies, many people do not realize that the synergy effect is more important than each individual theory. This synergy effect will help most of an organization. The organization must be aware that change does not happen overnight. Approaching the synergy effect can come slowly to many organizations. Challenging usually happens with some resistance to change. In these days, a small number of manufacturers have experienced the importance from this synergy effect. However, the number is still small.

This researcher recommends organizations, which are especially manufacturers to get involved more in quality management community. This Synergy effect has to be more about helping manufacturers, the manufacturer can take more comparable advantages from Six Sigma and Lean Manufacturing especially on Synergy effect.

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