DOING MORE WITH LESS:

A LEAN MANUFACTURING MODEL.

by

Balamurugan Sinnasamy.

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DEDICATION

This piece of work is dedicated to…

My wife, Devi………..who has always stood by me through thick and thin, and has been my main source of inspiration in my perusal of this MBA degree.

My precious sons……. Arrvin Raj and Sharrvin Raj.

And very specially to……Roshini

Our newly born baby girl……….who has come to complete our family.

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ABSTRAK:

‘Lean Manufacturing’ adalah suatu kaedah yang telah digunakan dengan jayanya oleh banyak syarikat , untuk meningkatkan keefisienan pengeluaran. Falsafah utama ‘lean manufacturing’ adalah untuk terus mengenalpasti dan menghapuskan pembaziran daripada operasi pengeluaran. Syarikat Q adalah sebuah pengeluar system pengestoran data luaran, yang kini menghadapi saingan hebat untuk terus hidup. Pengurusan syarikat ini bercadang untuk menggunakan amalan ‘lean manufacturing’ untuk meningkarkan produktiviti.Dalam kajian ini, keberkesanan tiga kaedah ‘lean manufacturing’, iaitu ‘batch size reduction’, ‘pull system’ dan ‘set up time reduction’ untuk meningkatkan produktiviti, telah dikaji menerusi kajian perkaitan ‘causal’.Keputusan menunjukkan bahawa ‘batch size reduction’ dan ‘pull system’ berkesan untuk memperbaiki metrik HPU and MCT sementara kaedah ‘set up time reduction; pula berkesan untuk memperbaiki metrik HPU, MCT dan Inventory Turn. Kajian juga mendedahkan keujudan factor-factor psikologi seperti sikap pekerja dan rintangan terhadap perubahan, yang turut mempengaruhi keberkesanan kaedan ‘lean manufacturing’.

ABSTRACT:

Lean Manufacturing is an operational tool that had been successfully used by some companies in the past to improve manufacturing efficiency and reduce cost. The main philosophy of lean manufacturing is to eliminate 'waste' from manufacturing and with that, improve efficiency of operational resources. Company Q is a computer 'back up drive' manufacturer who's faced with a desperate need to improve efficiency, in order to stay competitive. The management of the company decided to adapt lean manufacturing techniques, to achieve this. In this experiment, the effectiveness of 3 lean manufacturing tools (batch size reduction, pull system and set up time reduction) in improving manufacturing efficiency at Company Q, was tested through 'causal studies'. The results revealed that, these tools are indeed able to improve manufacturing efficiency but it's effectiveness is metrics specific. Batch size reduction and pull system are able to improve MCT and inventory turn significantly while set up time reduction is able to improve MCT, inventory turn and HPU significantly. Our experiment also exposed the effect of 'behavioral' factors such as resistance to change, in successful implementation of lean manufacturing. Change management was necessary to make this initiative a success in Certance.

LIST OF APPENDIXES:

Chapter 1:

INTRODUCTION:

1.1 Situation Background:

The last 10 years have been a very challenging time for the computer industry. Computer manufacturers, as well as computer related component manufacturers have been continuously threatened by price erosion. According to Fortune magazine (Feb 2nd, 2000), on an average, computer component prices have been eroding at a rate of 5 % per quarter (equivalent to 20% erosion per year). To make the situation worse, this erosion is happening against a backdrop of continuous enhancement in technology, mainly in storage capacity and speed. This means, computer manufacturers have to continuously reduce their selling price, while investing heavily in 'research and development' in order to improve the product capability.

There're many reasons for the current situation. The main one is notably, the availability of excess installed capacity in the industry, relative to demand. In early 1990s, all major players in the computer industry, namely Seagate, Maxtor, Western Digital, Quantum, Hewlett Packard and IBM began installing high manufacturing capability all over the world, in anticipation of a significant spike in customer demand. Due to various economic and world political reasons, the anticipated spike never materialized. Instead the global demand shrunk, causing a surplus in computer market. The result was a fierce price war between all major players (Forbes magazine; Feb 2000) .

These changes has also brought about a situation where the customer is totally ‘in charge’ and dictate all the terms. “The customer is king!” , says Steve Luczo, CEO and President of Seagate Technologies (Making Waves, Seagate; Oct 2000). Companies have to react to the ever changing customers’ demands, in order to maintain their business. So, flexibility and speed are the main factors that determine competitiveness of a company. ‘The big eats the small ’, is no more the order of the day, instead it’s ‘the fast eats the slow’.

A similar dilemma is faced by Company Q , which is an American based multi national company, specializing in manufacturing of ‘data protection solutions’. Over the last 2 years, Company Q has been continuously losing market share of it’s core product (the tape based backup drives, known as the ‘LTO Ultrium drives’), to it’s main competitors, Hewlett Packard and IBM. To keep up with competition, Company Q has had to continuously reduce selling price, thus reducing profit margin to almost the ‘break-even point’.

1.2 Company Background:

Company Q is a world leader in innovative, cost-effective data protection solutions for companies of all sizes. The company produces an extensive range of tape backup and data protection solution products designed to meet the backup and restore needs of virtually every platform from notebooks and PCs to enterprise servers.

Company Q is dedicated to being a worldwide leading supplier of innovative, cost-effective data protection solutions. With more than 12 million tape devices installed and 136 tape-related patents, it is recognized as a worldwide leading provider of tape drive and data protection solutions. Headquartered in Costa Mesa, California, Company Q has more than 1,000 employees in manufacturing operations, distribution, product development and sales worldwide.

Company Q's sole manufacturing facility is in Penang Free Industrial Zone, Phase 1. Built in 1976, this facility resides on a land area of 3.6 acres and has build up area of 103, 000 sq feet. There're a total of 650 employees in this facility.

The core production activity of this plant is making LTO (Linear Tape Open) drives. It includes machining operations, manual assembly operations as well as testing. The nature of the processes are semi-automated. While high technology and precise equipments are used intensively in the machining and test areas, the assembly lines are highly human dependent.

1.3 Problem Statement:

Over the past few years, Company Q has been under continuous pressure to reduce operating cost and improve product delivery speed. It's manufacturing cost, which was thought to be excellent and 'best in class', just two years ago, is just not good enough now. The competitors are doing better and it has to keep up. The customers are also grumbling about their occasional failure to react to demand changes fast enough.

However, the manufacturing team is at a loss. Company Q is already practicing 6 Sigma methodology in it's engineering activities. 6 Sigma has enabled the company to improve it's process yield and resolve key quality issues successfully. It has given the company's engineering team, a very structured way of analyzing issues and deriving solutions. However this methodology has not been able to improve Company Q's operational efficiency. Major operational metrics have been stagnant for a long time.

Company Q's management team is in a dilemma over this problem. They know very well that the company's manufacturing efficiency has to improve and it has to happen fast. Failing to do so will result in the Company losing it's competitiveness. They might become non profitable, which will make the company a burden to the whole organization.

The management team's problem statement;

> " ***The manufacturing efficiency of Company Q is not good enough to keep up with the competitors. If efficiency is not improved, the company will soon become non profitable***. "

1.4 Research Objectives::

The management team of Company Q feel that they cannot make significant changes by improving their current 'traditional manufacturing' model. They know that a new, revolutionary model has to be adopted. Lean Manufacturing, is the latest manufacturing model that is gaining popularity and is much talked about as ‘the’ manufacturing model of the 21st century.

The management team is keen on implementing lean manufacturing in Company Q. However, they have to be convinced first that lean manufacturing is the right model for them. This is especially important because the implementation cost of lean manufacturing initiative is very high. Investment has to be done on training materials and employees’ time. According to Moore and Gibbons (Gibbons, 1997), not all companies that has implemented lean manufacturing, has been successful. Many companies have dropped the initiative after claiming that lean manufacturing was not suitable for their environment, and has caused efficiency to drop instead. Among reasons stated by Moore and Gibbons for these failures are inability of employees to accept the lean manufacturing philosophy and implementation flaws. If a similar situation occurs in Company Q, , the potential interruption to manufacturing and subsequent efficiency loss can be very significant and damaging. This can in fact expedite the failure of the company. In summary, the cost of failure is just too high.

Thus the management wants to find out whether Lean Manufacturing will really be able to improve Company Q’s manufacturing efficiency, before deciding to go ahead with this model. They want a firm answer to the question:

“ Will Lean Manufacturing model cause manufacturing
efficiency in Company Q to increase? “

Company Q's management has identified their major areas of concern to be their production operating cost and product delivery speed to customers. Any improvement pursued should be focused on these two areas.

Before investing money and efforts in full implementation of lean manufacturing initiative, the management would like to validate their effectiveness to improve manufacturing efficiency in Company Q. They would like this validation be done through a scientific research.

The term 'manufacturing efficiency' refers to the measure of how well a company utilizes it's resources to achieve maximum profit. A company that has very high manufacturing efficiency will use all it's resources (like manpower, machines, material, space and time) to the fullest possible, and get maximum return out of it.

The metrics that will be used in this research to measure manufacturing efficiency are labor hours per unit (HPU), manufacturing cycle time (MCT) and inventory turn. By measuring these 3 metrics, the efficiency level of the manufacturing operations can be determined.

The investigation questions that are going to be explored in this research are:

1) Will the implementation of 'batch size reduction' tool cause Company Q's labor hours per unit (HPU) and manufacturing cycle time (MCT) to go down, and the inventory turn to go up?

2) Will the implementation of 'pull system' tool, cause Company Q's labor hours per unit (HPU) and manufacturing cycle time (MCT) to go down, and the inventory turn to go up?

3) Will the implementation of 'set up time reduction' cause labor hours per unit (HPU) and manufacturing cycle time (MCT) to go down, and the inventory turn to go up?

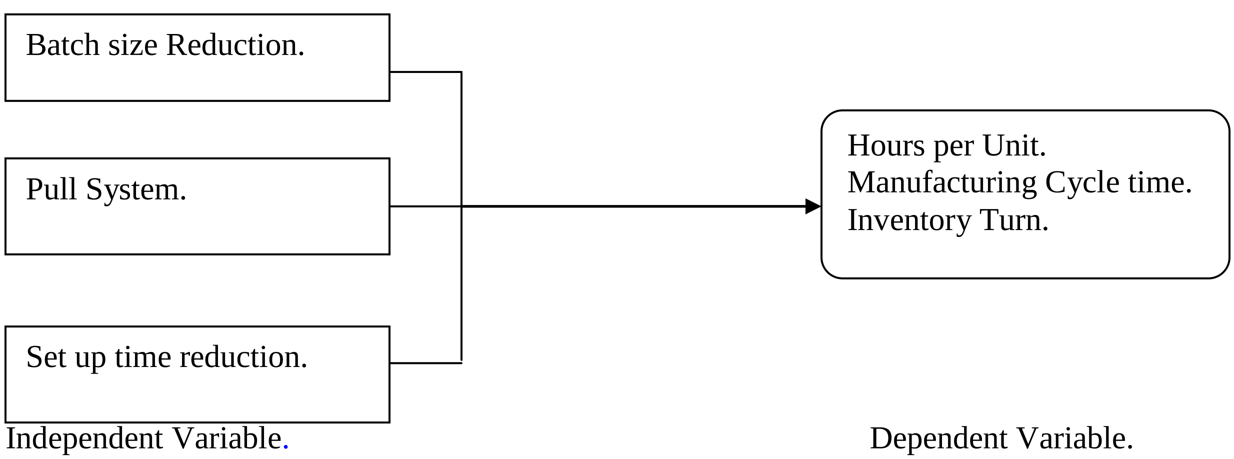

Figure 1: The diagram of relationship between variables is shown below

1.5 Benefits of the study*:*

This study will provide several benefits to the target organization. Among them are:

1) Provide justification for capital budgeting (for the cost required if plant wide implementation is to be pursued).
2) Provide assurance to management, on the suitability of lean manufacturing concept for their company.
3) Test out the intended lean manufacturing model in a small scale thus verifying and validating it's effectiveness, before plant wide implementation. This will reduce the risk of failure.
4) Provide the company's employees (at least those involved in the study), a general overview of the lean manufacturing concept, thus prepare them for change.

5) Identify all the potential barriers to lean manufacturing implementation. This can be done by observing employees behaviors and reactions in the course of the research. Understanding these factors is essential to ensure success, if implementation is to be carried at a larger, plant wide scale later

1.6 Variables Definition:

HPU (hour per unit) : This is a measure of the amount of labor hours that are used to produce one unit of final product. It is a very common metric that is used in most manufacturing organizations, to measure efficiency. Lower 'hpu' means that the organization is more efficient.

MCT (manufacturing cycle time):

This is a measure of the amount of time taken to produce one unit of final product, measured from the time the unit is loaded into the first operation, until the time it completes the final operation. It is typically used as a measure of the speed of a manufacturing organization. Lower 'MCT' means that the organization is able to make products faster, to meet customer demand.

Inventory Turn: This is a measure of the amount of inventory that are 'tied up' in the manufacturing line. It is derived by dividing the COGS (costs of goods sold in a year) with the value of total inventory available on the line, at the particular time. Higher inventory turn means that the amount of 'tied up' inventory is less. Typically, organizations will like to have lower inventory because inventory is actually 'idle asset ' or money that is tied up and not productive.

Chapter 2:

LITERATURE REVIEW:

2.1 Introduction to Lean Manufacturing:

The concept of Lean is by no means, a new philosophy. The earliest sign of Lean concept can be traced back to the 1950s, when Taiichi Ohno of Toyota Motors, adopted the ‘supermarket model of inventory control’ (Suzaki, 1987). It was a concept adopted from the inventory management system used by supermarkets, and later came to be known as the Just In Time (JIT) concept.

However Lean, as a conceptual framework, was only popularized in many Western industrial companies since the early 1990s, after the publication of the book, ‘The Machine that Changed the World’, by Womack (Sanchez ,2001). The diffusion of lean manufacturing was first developed among the auto manufacturers. Thereinafter, it was studied in other industries (Womack & Jones, 1996).

The interest on lean manufacturing was mainly based on empirical evidence that it actually improves Company’s competitiveness (Billesbach, 1994; Lowe et al, 1997). According to Sriparavastu and Gupta , the primary motivation for Companies to introduce lean manufacturing concept was to increase productivity, reduce lead time and costs and improve quality (Sanchez, 2001).

Since 1990, various studies have been pursued in the lean manufacturing field. There has been an enhanced interest among scholars and researchers to study lean. These studies, while being much diversified in nature, can be clustered into two main categories.

The first category was popularized by scholars such as Karlsson and Ashlstorm have worked on developing operational models based on the conceptual framework created by Womack in 1990. These researchers developed models that are applicable to implement lean in almost all types and sizes of industries. Later there were even models created for lean implementation in non-production related areas, such as 'lean office' (Juroff, 2003).

The second cluster of scholars, like Avella et al , concentrated their efforts in studying the diffusion of lean manufacturing strategies within manufacturing companies. They attempted to identify universal metrics that can be used to measure lean success across various industries (Juroff, 2003).

Both line of studies have contributed very significantly to the development of lean manufacturing concept to become recognized as 'the' manufacturing model of the 21st century'. Many organizations have started looking at lean, as no more an option, but rather a mean for survival. The late 1990s have seen the fastest growth of lean concept.

As old as lean is, and as wide as it's being recognized, it is still an alien concept among many manufacturing organizations in the world. Of the 30 – 40 % of US manufacturers who claimed to have implemented lean principles, only about 5% are truly running lean manufacturing operations (Simpson, 2003). Thus, it is safe to say that lean is not an universal concept that guarantees success for all organizations, under all circumstances. Lean is a very powerful concept that is capable of improving manufacturing efficiency, but the context of it's implementation is very important to ensure success. It has to be properly modeled to suit the target organization and the implementation process need to be customized to suit the target employees.

2.2 The 7 wastes of manufacturing.

The most universally accepted definition of lean is that of Womack (1990); lean is a concept of 'eliminating waste' from manufacturing. According to Womack, any activity that does not add value to the final product of the organization is waste. The only things that add value to your product, are things that effects the final outlook and the functionality of your product. Anything other then these, are waste. Eliminating this waste is at the heart of the crusade of lean manufacturing.

According to Simpson (2003), in a typical manufacturing plant, only 0.5 – 5.0 % of the activities really add value to the final product. This means, an unbelievable 95 – 99.5 % of the company's time is classified as waste. While sounding unbelievable, this is the very reality of traditional manufacturing environment. Traditional manufacturing companies are typically large, and has plenty of inventory, plenty of storage space, many equipments and large workforce. In short, they typically run with a large amount of resources. The reason why they require such large amount of resources is because of the presence of high amount of waste in their process.

The manufacturing waste can be classified into 7 major types (Womack and Jones, 1996). They are:

i) Waste of overproduction : producing more then what is required by the customer or producing goods or services before it is needed. By doing this, the organization uses up resources to build products that the customer is still not willing to pay for. Thus the organization is tying up asset. It is known as 'idle asset'.

ii) Waste of transportation : movement of materials, products or information that does not add value to the product (or service) of the organization. Excessive transportation will use up extra resources, extra space and potentially cause quality problem to the final products.

iii) Waste of waiting : inactive or lost time created when material, information, people or equipment is not ready. These will cause inefficiency in use of resources such as equipments and manpower. The resources are not fully utilized due to all the waiting time.

iv) Waste of motion : any motion that is not necessary to successfully complete an operation or task. Excessive motions such as walking and searching for tools, fall into this category.

v) Waste of over processing : efforts that create no value from customer's viewpoint. Excessive inspection and cleaning falls into this category. The customer do not care for and do not pay for all these extra processing done in the factory, thus they're actually waste.

vi) Waste of inventory : more material in hand then what is required to meet the customer's immediate demand. Inventory is also idle asset. It is 'money being tied up' and not working for the organization.

vii) Waste of defects : work that contains errors, rework and mistakes or lacks something necessary. The organization has to bear the cost of all these defects. Thus they will cause adverse impact to it's cost.

Thus, lean manufacturing concept improves manufacturing efficiency by identifying and eliminating these wastes. As these wastes are eliminated, the amount of resource required by the company will become less. As we keep eliminating more and more waste, the resources required will become less and less. This is the core concept of lean manufacturing, to 'do more with less' (produce more output with less resources). It's a benchmark against perfection, a continuous improvement process that moves the company’s manufacturing operations closer and closer towards perfection.

2.3 The lean toolkit:

Since Womack’s ‘The Machine that Changes the World’ (Womack, 1990) and ‘Lean Thinking’ (Womack, 1996), various lean implementation models have been studied and implemented. All of them were created based on the original, conceptual framework by Womack (1990 and 1996). While these studies vary greatly in their terminology and definitions, it is still possible to draw a commonality among the various models published. There’re 10 major methodologies or tools that are used by most researches in lean initiatives. They are ‘batch size reduction’, ‘set up time reduction’, ‘error proofing’, ‘’shop floor management’, ‘total productive maintenance’, ‘ pull system’, ‘theory of constraint’, ‘layout optimization’, ‘change management’ and ‘value stream mapping’.

Womack clearly states that organizations have to choose lean tools that are most appropriate for them. The first step is to have an in depth understanding of the main areas in the organization that requires improvement or that is failing to meet the corporate goals. This can be obtained through observation or through discussion with the company’s management team. After that, lean tools that are capable to address those specific areas have to be selected and an implementation plan has to be drawn using them (Womack, 1996).

The target organization of this research, Certance is primarily concerned about production cost and product delivery speed. The company's corporate management has already identified these as areas that need to be improved by the manufacturing facility. The operational metrics that are closely related to production cost and product delivery speed are HPU, MCT and inventory turn. Thus, these 3 metrics will be used as the mean of measuring production efficiency in this research.

By analyzing the primary contribution areas and strength of each one of the lean tools, as described by Womack , 'batch size reduction', 'pull system' and 'set up time reduction' are identified as the most relevant tools for this research. These tools are primarily recommended for cycle time reduction and production cost reduction (Womack, 1996). They're also recommended as the most basic ones and most suitable for early stage of lean manufacturing implementation. Since Certance is only starting it's lean manufacturing initiative now, it's most appropriate to start off with the most basic tools, before venturing into the more complex ones.

For the purpose of this research, focus will be given on the above mentioned lean tools. Definition of each one of these tools is presented below:

viii) Batch size reduction : The concept of reducing batch size of products, thus reducing the waiting time or queuing time of parts at each operation. This will reduce the waste of waiting and the waste of inventory (Womack, 1996).

ix) Set up time reduction : A concept of reducing the time incurred to convert capital equipments from one product / model to another. This will give flexibility to the production line to change products / models, as required by the customer, thus reducing the need to keep inventory. This tool will help to reduce the waste of inventory (Womack,1996).

xiii) Pull system : The concept of producing components or finished goods , just in time to be sent to the customer and just in the quantity required by the customer. The customer will pull the parts when he requires it. This concept is also known as JIT (just in time). It reduces the waste of inventory (Womack, 1996).

2.3.1 Batch size reduction:

The use of 'batch size reduction' as a lean tool for reducing manufacturing cycle time can be seen in studies carried out by Miltenburg. Miltenburg proposed the concept of 'one piece flow manufacturing on U shaped production line' , as a mean to reduce manufacturing cycle time. One piece flow is the ideal state in batch size reduction.. One piece flow means a batch size of one, which is the ideal case in inventory management. The U shaped concept enhances visibility on material flow, to allow control by visual monitoring (Miltenburg, 2001)

According to Womack, batch size is important to reduce product's waiting time or idle time. If the batch size is 10; while one part is being processed on, the remaining 9 parts will be waiting. This is idle time or the waste of time. Womack argues that, beside reducing cycle time, reducing batch size will also improve productivity because there's less time spent now on handling excess inventory , thus reducing the waste of handling .(Womack, 1996).

From these findings, batch size reduction appears to be the most likely tool to reduce the inventory in a manufacturing factory. By reducing the size of production batches, we can directly reduce the amount of inventory that are being processed and waiting to be processed in the factory. Reduction in inventory is reduction in idle asset.

2.3.2 Set up time reduction:

'Set up time reduction' is a lean tool that provides a methodology for quick conversion of key equipments from one product / model to another. This is done by moving some of the conversion steps into preparation stage, so that they can be carried out while the machine is still running. This will reduce the effective equipment downtime, thus the loss of production time (Womack, 1996).

A significant example of set up time reduction success story is the case of Richard Industries in Cincinnati, Ohio, a manufacturer of specialty valves for a variety of industries (Albert, 2004). In 2002, this company was hit by a crisis that threatened it's survival. One expensive equipment's capacity was pacing their output. The equipment had to be converted to process different products and each conversion took 50 minutes. Thus when they received many small orders from various customers, a lot of time was being wasted on conversions. Inventory was always piling up in front of that operation and slowing down material flow to the backend processes.

By using set up time reduction methodologies, they reduced the conversion time to 27 minutes. The output was almost doubled while the lead time was reduced from weeks to days. The company was able to make more products, faster thus satisfying all customers.

Womack (1996) describes the effect of set up time reduction like flow of water in a stream. When there's a bottleneck point in the stream, the whole flow will be slowed. Once the bottle neck is released, the water will flow faster and in higher volume. Similarly, in manufacturing, increasing the capacity of a bottle neck operation will cause the inventory to flow faster, thus increasing the output of the whole factory.

2.3.3 Pull System:

According to Heizer and Zender (Aghazadeh, 2004), Pull System or Just-In-Time (JIT) is a problem solving philosophy that was invented by the Japanese in the 1970s, and first adopted by Toyota. With JIT, supplies and components are pulled through a system when and where they're needed. The purpose of this strategy is to cut cost, eliminate waste and use all employees as efficiently as possible. Heizer and Zender further stated that inventory and time are not exceeded in a JIT system, so any costs related to unnecessary inventory are done away with and throughput improves.

Fullerton has studied the impact of pull system or 'just in time' (JIT) system on different manufacturing environments, and validated it's effectiveness. The pull system, according to Fullerton, is able to improve cycle time and inventory turn. It works by limiting the amount of inventory loaded into the production line, to the required quantity only. This works on the theory that excess inventory causes unnecessary 'idle time' for production units and extra handling as well as transportation efforts of production units. This is waste and a source of inefficiency, that has to be eliminated.

Womack, (1996) defines pull system as the method of producing part just in the quantity required by the customer and just at the time it's required by the customer. The customer here does not only refer to the external customer but also the internal customers. For every operation, it's immediate customer is the next operation that receives parts from it. So, pull system is a methodology whereby every operation 'pulls' parts from it's previous operation. The 'pull' is actually the trigger for the previous operation to produce parts. If there's no pull, then the operation will not produce parts. Thus there will not be any access parts in the pipeline at any time.

Wood, (2004) reviews the advantage of pull system in contrast to the more traditional push system. Push system is a forecast based system, whereby products are built per a given forecast (usually by the marketing people). This method has a serious flaw because in most companies (especially in volatile market environment), forecasts are hardly ever accurate. The result is we manufacture to a plan based in this forecast regardless of actual usage, and might end up overproducing. This is referred by Wood, as 'management by opinion'.

In sharp contrast, pull system does not use a forecast. It has no need since it is configured to manufacture and replenish product that has been used. This, according to Wood, is 'management by fact' and is more effective in dealing with market volatility and unpredictability.

Wood however cautions that pull system is not an universal model and has it's limitations. It is more difficult to apply on irregular and sporadic items. As it is based on replenishment, ongoing demand has to be assumed. In terms of product types, pull system is best used for 'runners' and 'repeaters'.

2.4 Is lean an universal model ?

While the proponents of lean manufacturing insist that it will supersede both mass production and specialized batch production in time to come, many researchers chose to disagree. According to Cooney , while lean practices have been adopted by many manufacturers, batch processing has an enduring value from both a work design and a manufacturing process design perspective. He argues that the 'pull system' model (which is a central practice of the lean model), is dependent upon a range of conditions being met. It depends on production leveling within the enterprise and within the manufacturing chain, and when this cannot be achieved due to business conditions or the nature of the buyer – supplier relationship, then batch flow is more practical (Cooney, 2002).

Going by Cooney's argument, lean manufacturing can be considered as only a partial model of manufacturing system. Companies with mass production system can adapt lean practices as additional tools for improvement. This argument can be accepted only based on the understanding that lean implementation is a long process or rather a long journey. No company can make a clean switch from a traditional production model to a lean model, with immediate effect. Changes have to happen gradually, and they do indeed start with the adaptation of some lean practices into the existing production model. However, in the long run, there has to be a transition towards lean manufacturing.

It is felt that all companies, regardless of the nature of it's business or the nature of it's supply chain relationship, has to start the journey towards lean at one point or another. The difference among them will be the chosen model and the chosen mix of lean tools to be applied, which will have to be customized to suit it's own business nature and environment.

The studies conducted by Hunter (2003a) supports the argument that lean is the key to manufacturers' success in the 21st century. According to Hunter, the greatest contribution of lean concept is giving flexibility to react fast to changes in customer's demand changes. With a very short cycle time and just in time inventory flow, manufacturers can provide customers with any product they want, at any time it is needed. This flexibility is the most critical survival factor in 21^{st} century businesses, when competition is most intensified and customers are most demanding (Hunter, 2003).

2.5 Is lean a formula for success or a formula for failure?

One of the most successful lean success stories is the Toyota story (Robyn, Jonathan & Benjamin, 2003). Toyota announced 2003 profit of $12 billion, at a time when the ‘big 3’ (Ford, GM and Chrysler) are struggling for scraps. The Toyota success is largely contributed to the lean manufacturing model which it had ‘invented’ and since mastered. Other automobile giants are struggling to keep up and had lately started adapting the Toyota model. Dell and Trane are other major organizations that have used lean manufacturing models successfully to stay way ahead of competitors.

According to Pierce (2000), it is not always easy to justify the implementation of lean manufacturing program . This is mainly due to productivity drop in the early implementation stages which is strongly discouraged under the traditional management accounting systems. This is indeed true and should be expected in not only lean manufacturing but any new initiatives implemented. Change is always interruptive. Whenever a change is implemented, there will be a transformation period where the stakeholders will go through the process of adapting to the new systems. During this period, there will be confusion, uneasiness and resistance. Performance level will drop temporarily due to this.

According to Phillips (2002) , lean manufacturing initiatives failed in a lot of US organizations due to lack of true support from the shop floor operators. No matter how good your labor balance may look on paper, it will absolutely fail if the workers themselves are not involved in helping establish the balance. Even when theoretical balance is achieved, without mutual operator assistance and support, it will be a hopeless task in convincing people to change the way they are doing things. A lot of time, lean manufacturing requires cultural changes for the people. Such changes are difficult to make (Phillips, 2002).

Another reason stated by Phillips (2002) for failure of lean manufacturing in large organizations is that these organizations are often stuck with existing material-control / product – costing systems that were purchased for millions of dollars. Changes to operating model might require changes to these systems as well, which will often be very costly. As a result, organizations often attempt to implement lean manufacturing without making appropriate changes to the systems, to support it. This cause mismatch and dissatisfaction among employees and result in them not supporting the lean manufacturing initiatives (Phillips, 2002).

The third issue mentioned by Phillips is lack of support from top executives of the organizations. They often ‘talked the talk’ but would not ‘walk the talk’ when it came to