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An analysis of managing waste and decreasing lead time in a medium sized manufacturing company

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AN ANALYSIS OF MANAGING WASTE AND DECREASING LEAD TIME IN A MEDIUM SIZED MANUFACTURING COMPANY

An Abstract of a Thesis

Submitted

in Partial Fulfillment

of the Requirements for the Degree

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ABSTRACT

The importance of managing waste and reducing lead time in manufacturing cannot be denied. This study provides knowledge about both topics in a medium sized manufacturing company. The methodology that is used in this research is mixed methodology. Interviews were done with managers, and they were analyzed qualitatively. The next part is the quantitative research part that is done by asking employees via questionnaire. This study provided the close concepts of JIT (Just in Time) and waste management. Management must be committed to change, to train everyone to the new culture, to ensure that the organization's culture fosters employee participation, and to monitor results over time. At the end of this paper, ideas are explored for the medium sized manufacturing company to minimize their waste and reduce their lead time.

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CHAPTER I

INTRODUCTION

Background

Today, manufacturing companies around the world strive to improve their manufacturing operations to ensure their survival. The medium size company that I worked for wanted to reduce waste in all areas of plant operation. Often the most efficient way to reduce waste is through the study of cycle time of each product. In 1997, the Center for Quality Management (CQM) described the benefits of reducing cycle time:

- The cycle time reduction pleases clients and customers and immediately responds to their needs.
- With cycle times, manufacturers are better able to rapidly introduce new products and services to compete with other companies.

Upper managers are working hard with the management of the plant by reducing fixed costs, especially labor costs, while maintaining customer satisfaction. A key to reducing fixed costs is the reduction of the setup time of the manufacturing cycle from order to delivery. Companies have used lean manufacturing principles to develop a production system called "modular," implemented in September 2002. In the modular system, the manufacturing cycle is designed so that the selected pieces are made together, avoiding redundant cycle time and reducing duplication and time out. Workers in this system must be trained and more flexible than workers in conventional manufacturing systems.

Rationale

Some companies have proven the modular system with the reduction of the floor assembly time compared to a conventional mounting system. As a result of the new mounting system, companies have managed to double production volume in comparison with the conventional mounting system. Despite these impressive results (50% reduction in time on the floor with the new mounting system), companies believes that further development of the modular system will result in a further reduction of time on the floor (Roy, 1988).

Based on my observation during my time in the company relations with suppliers about their quality and reduction of costs would be an important study area. Again, both supplier and assembler must understand each others' business to ensure that each will succeed financially and with a high quality product. One cannot survive without the other. Waste reduction and cost control is vital for both to survive, and the assembler cannot forget this fact. Finally, this research study seeks to improve the interaction between marketing and sales and distribution networks to provide a better understanding of customer needs and wants compared to manufacturing capabilities to further enhance a "pull" system and to challenge the system of production flexibility and program level.

Theoretical Framework

In a production environment which is constantly changing, with high turnover rates, where the trend is to move people into better positions with new people hired to fill in the opening, an easy planning production tool is essential. A simple method would prevent many common mistakes and help to ensure that the procedures which have been working will remain in use until better ways of doing things are established. That is, the methodology presented is intended to demonstrate the principle that it is feasible to keep waste to a minimum and meet customer demand (Wallace, 1995).

The waste minimization initiative can be achieved with existing resources and the same basic methodology of production. All it takes is a paradigm shift in how manufacturing processes are currently planned. Lamming (1993) found that the production program has a strong influence on the production of waste, when the change from one product to another involves the direct generation of waste.

Manufacturing organizations typically produce different products. Often, however, processes, materials, and equipment used for each product are similar and therefore offer opportunities for improvement. This may require the relocation of processes and equipment. Some organizations may be reluctant to change the distribution of facilities to create cells and to facilitate the flow due to the burden of validation requirements. The organization should evaluate the cost and effort made by this validation compared to the potential benefits. The team of lean implementation must provide the management with a cost-benefit analysis to ensure that the administration is committed to the change of inclination (Roy, 1988).

An organization can identify many value streams. These methods include analysis of product volume number, or part routing, and analysis of the product. The organization has a significant return on investment when ideas are applied to the continuous improvement of the value chain that represents the majority of the products or parts produced. This is the beginning of the analysis method of product volume. This method is especially useful for organizations with high volume and low variety of product mix. In contrast, analysis of product routing is useful when there are a variety of high-low volumes of product types. For this technique, the organization creates a graph showing the product or process parts with similar routes. Product share of machines or sequences of operations are good candidates for continuous improvement, and improvements in process will have a positive effect on various products or parts (Lamming, 1993).

The process for sustained success focused on high-level application development or revision of a full manufacturing company in a lean production system. Future research in the production of lean tools specific for each step of the process should be conducted for better operational management and standardization. The relationships among the social partners play an important role in the impact of a manufacturing plant and in the development of a lean enterprise. The work is fundamental to the successful implementation of lean principles. How to accept the work of accountability for efficiency and improving quality in a union shop determines the level of confidence. This should give confidence and foster a learning environment (Kenny, 1979).

Statement of Problem

This medium sized company is trying to improve lead time and decrease waste to reduce the delivery time of products to improve competitiveness. Improving lead time and decreasing waste is done by implementing effective production requirements. An approach that helps to reduce waste and improve lead time requires potential to reduce production cost for the manufacturer with little disturbance in production flow. Improving the lead time will help in faster production by recognizing those products will be produced together.

Purpose of the Study

The purpose of the study is to analyze the waste management and lead time in a medium size manufacturing company. This study will evaluate the effects of waste minimization and the reduction of lead time. For these purposes we have analyzed a medium size manufacturing company. We have used mixed methodology by asking employees to complete a questionnaire (Appendix A), and we have also interviewed managers, asking a few questions (Appendix B). By using the modular design as part of an overall effort will reduce fixed costs. The modular design reduces the multiplicity of parts and components to reduce installation time. In the past, production efficiencies have been achieved by grouping the selected pieces to be manufactured together, using common tools and sizes. For the inspection process, which takes place at the end, it was shown that the number of defectives produced is modeled as a reduction in the probability of a malfunction of the machine that makes the production of defective units. An improvement in quality allows a plant to increase production lot size, in the sense that improving the quality allows a facility to obtain economies of scale.

Despite the simplicity used to describe the basics of the waste minimization (WM) system, clear understandings are needed of the basic principles of WM. In other words, it is simplistic to say that "if the waste cannot be avoided, then produce the minimum amount possible in the process, and nothing more." In practice, to achieve what is involved behind this concept, it is necessary to make many changes and improvements to current industrial farming practices considered acceptable today.

Part of the answer to the needs of the current market environment has been the development of new methods of systematic design embodying the concepts of waste minimization. The main objective of these systems is that they allow manufacturers to eliminate emissions, either by not creating pollution in the first place or by the recovery and reuse of materials that would otherwise be discharged, while effectively maintaining the performance of their production requirements. A system that has proven effective in helping manufacturers to achieve these objectives is the process known as minimization of waste and green chemistry (Lee, 2004).

To increase their productivity, some medium size companies adopt a new manufacturing strategy called production demand, which was designed to reduce the delivery time from the customer order to delivery. The modular system is designed to provide quick delivery to customers, to minimize inventory to save the value added of manufacturing, and to allow immediate reaction of many types of options based on customer requests. Production in anticipation of demand was not unlike mass production. After a company receives a sales order from a customer, they purchase the production of machine parts from suppliers and begin manufacturing the products based on the customer's special request. Using the production demand, the delivery between when the customer placed an order to the shipment of the product was reduced, thus adapting to customer needs.

All industries are trying to reduce the delivery time of products to improve competitiveness. All companies must compete with its competitors to survive in their market. Strategies of each company are different, but all companies are fighting for the same goal which is to prevail over other competitors. Therefore, to increase competitiveness is an ongoing goal that all companies work toward. Thus, while Just in Time (JIT) improves resource utilization, unit costs may increase.

Statement of Need

Global competition has introduced, among other challenges, the need to react quickly to the complexity of the manufacturing process, rapidly changing technology, customization of products at high volume, and short product life cycles. The complexity of production and assembly processes has increased to the point that managers in this medium size company begin to have trouble keeping their factories running at a profitable level. The problem is compounded by the fact that production control decisions have a direct and measurable effect on the amount of hazardous waste generated by the process which, thereafter, must be treated.

Perhaps the greatest challenge and opportunity for mechanical engineering design systems is the 21st century of labor relations with the Earth's natural systems. As Industrial engineers, we offer solutions that ensure the optimization of the local industry is not at the expense of global optimization and sustainability. In a world where natural resources are shrinking and where resources for human rights are growing exponentially, the traditional notion of efficiency of industrial engineering that promotes increased consumption of natural resources unfortunately seems dangerously outdated and unsustainable.

Research Questions

The research questions that this study aims to answer are:

1. How do managers view their role in the company?

2. Do managers see any room for improvement in company processes?

3. How do employees view their role in terms of waste management and reducing lead time in the company?

4. Do employees see any room for improvement in company processes?

5. Do employees perceive that waste reduction will help the company become more profitable?

6. Do employees perceive that lead time reduction will help the company become more profitable?

7. What is the employee perception regarding the company they work for and what is their satisfaction level?

8. Is employee satisfaction related to lead time reduction or waste reduction?

Significance of the Study

This study evaluates and analyzes the inputs used and the solid waste generated in manufacturing companies. Focus is primarily on improving the efficiency of the production system to reduce waste materials. Despite the fact that the economic benefits are significant when considering options for cleaner production, cost-benefit analysis was not carried out on the waste minimization measures suggested in this study. Alternative options for production are presented in terms of best practices that could reduce or eliminate current waste, with the consideration of alternatives that can also result in cost savings.

Delimitation of the Study

One of the chief benefits of this study is that managing waste and decreasing lead time in a medium size manufacturing company profits the company as a whole. The utilization of goal-directed sampling is yet another added advantage which adds to the strength of this study, as it is effective for situations when the investigator wants to reach a directed accumulation of the people being sampled.

Overview of the Study

The study will provide information about the management of waste and decreasing the lead time in a manufacturing company. Chapter I will provide an introduction to the research topic, its relevance, and purpose of this research. Chapter II reviews the academic literature that is relevant to the topic of waste management and how lead time can be decreased. In depth understanding will be gained by reviewing the literature. Chapter III will be the methodology section, and it will provide knowledge about the methods which are followed in order to gain information. Chapter IV will discuss the results which are extracted from the respondents. It will show analysis of the opinions of the respondents regarding the topic. Finally, the conclusion and recommendations will be given in Chapter V.

Definition of Terms

This study will use the following terms:

Lead time: This refers to the time taken between receiving an order and placing it (Hobbs, 2004).

Structured interview: Doyle (2011) describes structured interviews as a fixed set of questions prepared prior to the interview and directed to all the interviewees in the same order.

Unstructured interviews: They are interviews not in order, although a set of questions may be prepared prior to the interview. In this case, the interviewee, based on their responses may be asked different questions (Doyle, 2011).

Semi-structured interview: In this interview, one develops questions for the purpose of probing for clarifications or information. They are mainly used to probe answers (Doyle, 2011).

Data Analysis: In a thesis, this is the process of data examination and investigation which is usually carried out through various theoretical hypotheses (Hobbs, 2004).

Lean Manufacturing (LM): Often simply, "Lean," is regarded as a production philosophy that considers the expenses of resources for any goal other than the establishment of significance for the end consumer to be wasteful, and thus a target for riddance (Hobbs, 2004).

Total Quality Management (TQM): This refers to an integrative philosophy of management for continual improvement of product quality and operational processes (Hobbs, 2004).

CHAPTER II

LITERATURE REVIEW

Manufacturing costs can be coarsely classified into two broad categories, those that are volume-related and those that are variety-related. It is widely believed that manufacturing processes experience economies of scale which implies that volume-related costs decline with longer and larger production runs (Porter, 1985). This occurs because the fixed costs of items such as production overhead setup are spread over more units reducing the burden rate for any one unit. The variety-related costs, however, increase with the number of different products that a facility produces. The underlying assumption is that resources are shared between products and because of changeovers the costs increase in the number of product lines that a facility supplies (Levitt, 1972). Thus, one can restate the decision alluded to earlier as determining the optimal product variety to produce, which balances the variety- and volume-related costs.

It is claimed that wider product lines lead to increased market share. This translates into higher production volumes, reducing volume-related costs and increasing profitability (Slade, 2007). The relative profitability of business lines finds that those with wider product lines had lower costs per sales dollars and higher profitability. The increased profitability can be caused by margins increasing more than costs. Thus, profitability and unit costs may be higher for firms with wider product lines (Jensen, 1982). Stalk found that reducing the number of products by half would decrease unit costs by 17% and increase labor productivity by 30% (Lee, 2004).

Just in Time

Just-In-Time (JIT) manufacturing arrived in the 1990s when domestic manufacturers faced stiff competition in product markets from their foreign counterparts. The competitors were primarily Japanese discrete manufacturers with lower manufacturing costs and consequently had the ability to lower prices (Hawkins, 1993). Their production systems were characterized by lower inventories, quick changeovers, high quality levels, and very sharp production lead times. These characteristics subsequently became identified with the JIT manufacturing system being used at Toyota (Grossman, 2007). After closer scrutiny, many firms realized the benefits created by a leaner production system and subsequently implemented systems tailored to the local environment, with characteristics similar to the Japanese JIT systems (Ohno, 1990). The adoption of these manufacturing methods triggered studies by academics that attempted to explain efficiency gains that result from JIT adoption. JIT is essentially a system of beliefs and attitudes combined with a collection of methods and procedures, all of which are shaped into a general management philosophy that describes how an operation should be managed (Imai, 1986). The management objective under JIT is to produce product only when it is demanded by the downstream operations or external customers.

With respect to the individual firm, there have been a number of studies that deal with balancing gains in demand against both economies of scale, or volume-related costs, and scope, or variety-related costs. The individual firm can also offer a greater variety of products to preempt other firms from entering a market. The market equilibrium associated with competition on the basis of variety has also been explored, and it is found that the degree of variety is limited due to either economies of scope in production or by the number of firms in a market (Dailey, 2003). The larger-batch sizes increase the work-in-process inventories in the plant, and longer lead times force customers to hold larger inventories. Some systems are characterized by short lead times and low inventory levels, but, to achieve these results, setup time must be reduced. Poor process quality causes the production of defective units which must be reworked and stored. This, too, increases production lot sizes to compensate for the defective units that are generated and leads to more inventory in the system (Hobbs, 2004).

Quality Improvement

An improvement in quality allows a plant to increase the production batch size, and in a sense the improved quality allows a facility to gain economies of scale. It shows that lower setup times allow a firm to offer wider product lines by reducing the economies associated with changeovers between products. Process quality improvements or fewer machine malfunctions favor wider product lines only if a facility is capacity constrained (Dailey, 2005). The addition of products reduces the volume produced for each product. In a sense wider product lines complement poor quality, if the firm can readily increase capacity. It is shown that the supplier prefers lower setup times if the manufacturer's variety decision does not affect the variety of parts that are supplied. If the increase in product variety causes a requirement for greater part variety, a supplier is unable to recover the entire increase in cost through the price mechanism. In this case, a supplier prefers higher setup times, which constrains the number of products that a manufacturer can offer (Alukal & Manos, 2006).

The trend towards "just-in-time manufacturing" and "lean production" illustrates this fact. The new technologies attempt to remove waste through reducing setup times, improving quality, rationalizing the supplier base, and reducing inventories. These methods act to reduce dis-economies that arise from multiple products sharing constrained resources. Thus, plants are better able to manufacture a larger number of products under these systems. It describes the impact of setup time reduction and quality improvements on a manufacturer's choice of product variety (Dailey, 2005). The model described in this work consists of a manufacturing facility that supplies a product in market consisting of consumers with heterogeneous tastes. The production stage consists of a single resource which is used to manufacture multiple products. The monopolist manufacturer chooses the number of products and the quantity to supply a market consisting of heterogeneous consumers. It is shown that setup time reduction enables the manufacturer to offer greater variety due to a reduction in the dis-economies of scope, in terms of changeover costs (Alukal & Manos, 2006).

Moreover, by offering more products the manufacturer is able to charge higher prices and increase revenues even though volume per product declines. This decline in volume further reduces batch sizes. Quality improvements or reduction in machine malfunctions that generate defective output also lead to greater product variety since defect reduction reduces the amount of rework that is needed. Rework increases with batch size, and improving quality allows the manufacturer to produce larger batches that are needed for wider product lines. The monopolist manufacturer is supplied pans by an external parts fabrication facility (Imai, 1986). The manufacturer's product variety decision influences the demand for parts faced by the supplier through affecting either the volume or the variety of parts demanded. The supplier, too, faces dis-economies of scope due to setup times in parts fabrication. In fact the supplier strictly prefers higher setup times if part variety increases as the manufacturer offers a wider portfolio in the product market. Skinner (1974) recognized the need to focus one's manufacturing effort on fewer products so as to achieve low costs and high quality through improved control. On the other hand there is demand for a greater variety of products due to heterogeneous consumer tastes (Levitt, 1972).

Manager Trade

Managers must trade-off the higher production costs against the greater revenues, from wider product lines, to arrive at the optimal number of products. Thus, the decision to determine the product mix is of vital importance to firms. A firm can also choose to alter its technology to better cope with wider product lines. A more flexible technology would reduce variety-related costs and enable a firm to offer greater variety. Manufacturing costs can be coarsely classified into two broad categories: volume-related costs, which decline with longer and larger production runs, and variety-related costs, which increase with the number of different products that a facility produces. The latter occur because resources are shared between products and changeovers between products. The costs increase as the variety produced increases. Moreover, an increase in variety would reduce the production volume for any one product, due to cannibalization of market share (Lee, 2004).

The individual firm can also offer a greater variety of products to preempt other firms from entering a market. The market equilibrium associated with competition on the basis of variety has also been explored, and it is found that the degree of variety is limited due to dis-economies of scope in production. The production and manufacturing literature concentrates on an individual firm and the impact of its technology decisions on the variety it produces or offers the market (Imai, 1986). The specific technology decisions that are considered deal with the flexibility of the production process, in terms of varying production volumes, or in terms of the number or types of products that are produced. DeGroote (2010) examined the problem faced by a monopolist in choosing between technologies that differ in their flexibility, in terms of production cost, to produce a multitude of products. He defined flexibility as a relative concept; thus, a technology is more flexible than another, if an increase in diversity of the product line induces a smaller increase in total cost for the first technology. His work assumed that an increase in variety has the same impact on production cost, as an increase in volume. DeGroote's analysis included studying the effect of setup time's reduction and process quality improvement on the product variety decisions of a firm (Alukal & Manos, 2006). Setup times are a large component of the variety-related costs since they reduce the productive time in a facility. Thus, reducing setup times would enable facilities to offer more products. In this work, quality improvements are modeled as a reduction in machine malfunctions, which generate defective output. Quality improvements reduce the amount of rework necessary on defective units. Greater variety leads to larger batch sizes which, unless accompanied by improvements in process quality, would increase rework (Porter, 1985).

JIT Principles

JIT principles have traditionally focused on reducing waste. Assembly operations are more receptive to this effort and should exhibit greater gains. This should also create systematic differences in the scale of RT adoption between facilities. A complete exposition of the results on systematic differences in JIT scope for plants at different stages of the value chain is provided in the discussion on the extent of JIT implementation. There is some anecdotal evidence of downstream JIT manufacturers exerting vertical control over their suppliers through the use of Electronic Data Interchange (EDI) and a broadcast system which enable a facility to offer greater product variety (Levitt, 1972). Moreover, manufacturers prevent their suppliers from increasing variety. Toyota has had the practice of sourcing only a single part from each supplier. Thus, an increase in the number of car models will generate an increase in the number of suppliers and not increase the variety for each supplier.

It is evident that raw material buyers and component producers had a smaller reduction in setup time than their downstream counterparts. This lends support to the argument that those benefits from investing in setup time reductions are not as great for upstream manufacturers. They are for facilities closer to the consumer. Upstream manufacturers may not have as much scope to differentiate products because of technology. For instance, electronic components are standardized and have little differentiation (e.g., computer chips) but have various uses in different models or groups of products. Moreover, there is some evidence that the number of components and sub-assemblies needed per product have declined over time. Manufacturers benefit from differentiating products late in the process by receiving higher margins and by allowing the supplier to achieve economies of scale. Thus, a component manufacturer has less of an incentive to invest in setup time reduction (Lee, 2004).

EDI (Electronic Data Interchange)

Electronic Data Interchange, or EDI, is a critical part of a JIT strategy that exercises vertical control over suppliers. It is not surprising then that a vast number of JIT plants use Electronic Data Interchange. Total Quality Management (TQM) has gained popularity because of the modern emphasis on quality improvement and reducing waste. One of the JIT principles is to improve the quality of both process and product and, in this sense, TQM is complementary to these efforts. Statistical Quality Control (SQC) is an older practice that attempts to improve quality through the use of statistical techniques. Processes that produce defective units are identified in a timely fashion and corrected promptly. Thus, quality-based information flows are improved.

The benefits of SQC are greater in JIT facilities since they put a premium on reducing waste. Supplier certification programs conducted by manufacturers require vendors to implement these techniques in their operations. Both TQM and SQC are commonly associated with modern manufacturing. Thus, their widespread adoption by JIT facilities is not surprising. TQM and SQC do not display differential adoption patterns within the value chain. All three technologies are non-specific to any manufacturing environment. Flexible Manufacturing Systems (FMS) describe technologies that enable firms to achieve quick changeovers between products. They consist of automated programmable systems which manufacture a wide variety of parts and components in less time than do human systems. They have great applicability in environments characterized by wide variety and small volumes (Porter, 1985).

Reduction and Manufacturing Cycle

Reduction of the manufacturing cycle time is considered an effective way of reducing manufacturing cost and delivery time. Lean Manufacturing is one method of how a company can improve their capacity to compete. In lean manufacturing, there are many other ways to enhance competitiveness, but the factors are basically accuracy of product, technological advantage, quality, and service/support. The idea of lean manufacturing is to reform the effort for enhancing competitiveness. Mazak has advocated that production must use Production on Demand (POD) and a modular assembly system for future developments. These two methods are aimed at increasing competitiveness by reducing manufacturing cost, sales price, and delivery (Alukal & Manos, 2006).

According to Matsunam (2009), the conventional assembly system has limitations to reducing manufacturing cost and assembly lead-time. There are three reasons for this. First, this system required a large assembly area to gather all the parts to assemble a machine. The smallest machine that is made at Mazak Corporation in Florence, KY, has about 159 parts. It is difficult to place all parts in a confined place, and parts lay around the floor, creating problems. Second, it is hard to find problems when they occur (Ishikawa, 1985). If processes or parts are delayed, production needs to be quickly informed of the problem. Production, however, has to manage many parts to assemble. It would be hard to distinguish what is missing. Third, the conventional assembly system has too much waiting time. Since the assembly system is a sequential operation, *other parts are just waiting to be assembled into the machine (Dailey, 2003).*

Modular Assembly

Assembly lead-time was wasted at this point. Due to these reasons, inventory, lead-time, and manufacturing cost would not be reduced in a conventional assembly system. In order to increase competitiveness, a company requires a manufacturing system that will further reduce lead-time and manufacturing cost. Mazak has created a new assembly system to meet these problems. The new assembly system is called Modular Assembly System (MAS; Hawkins, 1999).

The main theme of the Modular Assembly System (MAS) is to increase efficiency of the assembly area by integrating machine parts. This assembly system is aimed at lowering cost manufacturing, lowering cost distribution, and increasing delivery speed, while maintaining specifications, accuracy, and quality of products (Dailey, 2005). Currently, manufacturing enterprises, worldwide, are striving to improve their manufacturing operations to ensure their survival. Manufacturers want to reduce waste in all areas of plant operation. Often, the most efficient way to reduce waste is by studying each product's cycle time. In 1997, the Center for Quality of Management (CQM) described the benefits of reducing cycle time:

• Reducing cycle time pleases customers; customers like immediate responses to their needs.

• With reduced cycle times, manufacturers are better able to quickly introduce new products and services, in order to compete with other companies (Imai, 1986).

In the modular assembly system, the manufacturing cycle is designed so that selected parts are manufactured together, to avoid redundant cycle time and unnecessary repetition and to reduce waiting time. Workers in this system need to be trained and more flexible than workers in conventional manufacturing systems. Mazak has credited the modular assembly system with assembly floor time reduction when compared to the conventional assembly system. As a result of the new assembly system, Mazak has succeeded in doubling its production volume compared to its conventional assembly system. Despite these remarkable results (50% floor time reduction with the new assembly system), Mazak believes that further development of the modular assembly system will result in an even greater reduction in floor time (Dailey, 2003).

Manufacturing companies had to adopt a new manufacturing strategy called Production on Demand, which was designed to reduce the lead time from customer order to delivery (Hobbs, 2004). The modular assembly system was designed to provide quick delivery to the customer, minimize inventories to save manufacturing added value, and allow immediate response for the many kinds of options based on customers' requests. Production on demand was not forecasting production unlike mass production (Hart, 1997). After sales gets an order from a customer, production purchases machine parts from vendors and would start manufacturing products based on the customer's special order. By using production on demand, the lead-time from customer's order to product shipment was reduced, and this met the customer's needs (Hart, 1995).

Waste Management

Organizations strive to reduce costs and lead times while maintaining the highest quality. Since lean and the associated kaizen events aim to reduce waste, which leads to cost reductions, organizations can apply these philosophies to achieve the goals of world-class organizations (Hawkins, 1999). Overproduction waste occurs when production takes place earlier than is required by the next process (Dailey, 2005). The next process is any step in the value stream, including the customer. Waiting waste refers to the idle time of employees or equipment as they wait for the arrival of parts from the previous step in the process. Transportation waste refers to the excessive transportation of material, information, or parts through the facility. This category of waste occurs when steps of a process are located distant from each other when they could be located in or near the same area (Alukal & Manos, 2006).

Processing waste typically is a result of poor tool or product design. This waste includes unnecessary or incorrect processing. Inventory waste occurs when a process creates excess material before the next process or customer needs it (Hay, 1988). Defects cause waste of time, material, and other resources. Defects require sorting, reworking, or scrapping material that is not meeting specifications. Underutilization of talent and resources includes not utilizing personnel or other resources in areas in which they may apply their full potential (Hobbs, 2004). This underutilization is a waste of human potential and may lead to a lack of employee motivation and dissatisfaction, which may adversely affect the quality of processes and product. Each of these wastes is unnecessary and is a focus for elimination in the lean philosophy (Ishikawa, 1985). Overproduction is the most detrimental waste because it contributes to all the other wastes. Elimination of waste leads to improvements in resource utilization, lead time, customer satisfaction, and profit. It also leads to decreases in space requirements and product rejections (Dailey, 2005).

The principles of lean include a focus on customer-defined value, the elimination of waste, flow of processes, pull from the customer, and the pursuit of perfection. Muda (waste) is an activity that consumes resources without creating value for the customer. Type one muda consists of activities that do not create value for the customer but are necessary for the process. Type two muda consists of activities that are not required for the process and do not add value for the customer (Jacobs, 1991). Examples of muda include overproduction, waiting, conveyance, processing, inventory, motion, correction, and underutilization of personnel. Kaizen and lean principles are applicable to any type of organization (Katin, 1991). Searching the internet for articles related to the application of lean yields information from diverse industries, including automotive, healthcare, IT, services, banking, and construction. Although the thesis does not contain any new information, it reviews key management attributes, challenges faced, and results obtained by these organizations (Alukal & Manos, 2006).

Supplier relations concerning their quality and cost improvements would be an important area for further study. Again, there must be a trust between assembler and supplier to understand each others' businesses making sure that one or the other is not going to suffer financial or quality difficulties. One cannot survive without the other. Reducing wastes and controlling costs are vital for both to survive, and the assembler cannot forget that point (Kenny, 1979). Lastly, the study and improvement of the interaction between Marketing and Sales and the dealership networks will provide a better understanding of customer needs and wants versus manufacturing capabilities will further improve a "Pull" system and challenge the production system in flexibility and level schedule (Dailey, 2005). Again, it all starts with the customer, and by trying to meet customer demand without producing excessive inventories for dealers allows both the dealership and automotive company to thrive (Ohno, 1990).

Green Manufacturing Wastes

There are many environmental waste reduction measures used by manufacturers today. Environmental regulations have only established the need to evaluate companies' environmental waste objectively. When it comes to specific techniques to reduce environmental waste, this is where the programs of pollution prevention and waste minimization are effective. These programs focused primarily on tactical operational aspects of the manufacturing company, helping companies create continuous environmental improvement programs, such as structures with elements of the improvement teams and the tools to identify and reduce waste (Levitt, 1972).

The Industrial Revolution was almost a century old by the end of the 19th century as steam power and mechanical manufacturing had replaced most mechanical work performed by humans and animals. Medieval industrial life was dissolving in the wash of the new manufacturing wave of mechanization (McCarthy, 1992). Feudal manufacturing enterprises were being replaced by manufacturing organizations headed by organized management structures. From a manufacturing perspective, waste is defined as anything other than the minimum amount of equipment, materials, parts, space, and workers' time, which are essential to add value to the product. In industrial levels, liquid, solid, or gaseous waste materials are inevitably generated during the manufacture of any product. These wastes represent process inefficiencies leading to losses of valuable raw materials and energy (Levitt, 1972).

Manufacturing Process and Waste Management

The generation of residuals, which may become wastes, is a normal consequence of virtually all-productive activities. When materials residuals are returned to the environment they take the form of solid, liquid and gaseous wastes (Pojasek, 2008). Although some residuals can be recycled, or they can be treated using physical, chemical and biological processes, they cannot be entirely eliminated. A key precept in driving industry toward a pollution prevention approach is that pollution prevention is feasible and pays (Mayers, 2007). A thorough examination of the process, including its technical capabilities, potential applications and sales, inputs as raw materials, and outputs as products and wastes, is recommended to ensure that a pollution prevention project is analyzed in total (Nas & Jaffe, 2004).

Approaches toward Manufacturing Waste Management

Many companies in industrialized countries are becoming more proactive in their approach towards pollution minimization and waste management. Concepts and strategies that take a systems view of production processes are evolving to facilitate a progression towards environmentally sound business practices and to identify overall system improvements (Kroll, 2004). The concept of manufacturing ecology has emerged to describe how knowledge of naturally developed, closed-loop ecosystems can be applied to develop similar cyclical systems within and between industries. Cleaner production strategies have also come to the fore of environmental management practices, prescribing a preventative approach towards improving the environmental aspects of processes and products (Schmidheiny, 1992).

In general, the approaches are evolving from waste management to resource management. It is hoped that the environment will soon be seen not as a place removed from the world of human activity, but "as intrinsic to manufacturing decision-making whether industry is interpreted narrowly as a particular organization, or more expansively as the scope of human activity." This change in values and thinking is fundamental to conserve natural resources and preserve the planet's ecological integrity (Watts, 1990, p. 79).

Minimizing Manufacturing Waste

Past approaches to minimize manufacturing wastes have been met with only limited success. For instance, in the 1970's the common view was that "the solution to pollution is dilution," indicative of the lack of understanding for the scale and gravity of environmental issues. Recognizing the need to reduce pollution, this perception evolved in the 1980's to "command and control" mandates, requiring individual companies to implement "end-of-pipe" technology (Phillips, 1993).

Unfortunately, these traditional pollution control tactics often did not eliminate waste but simply shifted the location of the waste. For example, emissions control technology such as scrubbers on the smoke stacks of coal-fired, electricity-generating stations capture particulates and otherwise toxic emissions; however, this captured sludge must still be disposed of. Although this technology is successful in reducing the amount of pollution going into the air, it may simply divert it to landfills creating a new set of environmental concerns (Panizzolo, 1998).

This reactive approach towards pollution minimization does not address the need for resource conservation at the source, nor does it support innovative ways to reduce wastes through alternative practices (Osterman, 1994). Although regulations are still a necessary part of the solution, they are not sufficient to effectively address the expansiveness of the environmental problems caused by manufacturing activity. Hence, a more integrative and systematic approach is required (Ohno, 1990).

Manufacturing Organizations

The manufacturing organization can identify best practices to eliminate waste and to improve how the development process complies with these requirements. Opportunities for applying lean to product development include combining and streamlining process steps, using raw materials from preferred vendors, and creating document templates to ensure consistency and to eliminate the need to reinvent the development process with each new product. The goal of lean improvements is to address the entire process, not to apply improvements to a limited area without consideration for the remainder of the value stream (Levitt, 1972).

Implementing lean requires a change in thinking and culture as well as a change in processes. One method of fostering participation is the establishment of suggestion systems where management considers all suggestions and rewards employees for their contributions (Ohno, 1988). Without management commitment, employees will view lean as a management fad and will not participate fully in the culture change (Porter, 1985). Manufacturers are always looking for ways to increase workers' productivity, that is the rate at which products are produced, the amount produced, and the resources (work, time, and money) needed to produce them. There are many ways to increase productivity (Lee, 2004).

A manufacturer may focus on reducing labor costs, reducing production cycle time, or adjusting the quality or cost of materials. Companies search for the best way to reduce production costs, given the industry and the competitive situation they face (Neely, 1993). The Modular Assembly System is a parallel manufacturing process to reduce floor-time in order to meet customers' demand. Since the assembly hours and number of workers are the same in each process, the total labor cost does not change even though floor-time and lead-time were reduced using modular assembly system (Dailey, 2003).

CHAPTER III

METHODOLOGY

Research Methodology

The research methodology used to illustrate this report is both qualitative and quantitative data research. The information came from qualitative interviews done with managers and was analyzed qualitatively. Total numbers of managers are 13. The next part contains the quantitative research conducted by surveying employees via questionnaire. The position of the employees in the company was the basis for their selection in the survey. Total number of employees for the survey is 100.

Data Collection Method

Qualitative and quantitative methods are used in this research. The largest possible numbers of people are questioned in the quantitative method. The usual standard method is used in which the respondent cannot specify. It is more important to them but it should also complete the grid (e.g., check questionnaire). The survey method here is interview and questionnaire. The quantitative research emphasized numerical data, which is analyzed by specific mathematical method.

Data Collection Tool

In order to collect the quantitative data, questionnaires are used. They are used because they are the easiest way to collect the quantitative data in the shortest possible time. Also, universally it is accepted that questionnaires are the easiest way for the participants to understand the study intention. It is also easy for them to provide their feedback via questionnaire. Interviewing staff members is also an extensive way to collect the data required for analysis regarding the research objective. The social research qualitative interview plays a role in many variants. They partly integrate in the complex design.

The central data is based more and more on qualitative interviews. It came from Anglo American in the 20th century. The term is common in journalism. Although this is not scientific by definition, it is in fact situational. It is conscious and deliberate, where questions are asked and they are answered by others. The question-response asymmetry is decisive in qualitative interviews.

There are different forms of qualitative interviews:

- Interview intention
- Structure standardization
- Forms of interview communication
- Communication style

General Approach to Research

This study was done with the approach of taking into consideration the nature of the firm selected regarding this study and the kind of participants. All this was needed for the collection of data. Following are the fundamental motives of the research methodology:

- Final conclusion will be proposed at the end of the study.
- Quantitative and Qualitative approach will be used for the methodology.
- The utmost importance will be given to ethical branding.
- According to its need to the research objectives, data collected through analysis will be omitted or deleted.
- Flexible methodology will be used to add and remove information as the research progresses.
- In order to make vital recommendations, it is important that data should be reliable and valid.

Induction (Anonymous, 1991) is the logical procedure which compares the particular individual to the universal law which is in contrast to the process of reverse deduction. Induction is based on the assumptions in which observed events are proving to be true. The accuracy probabilities depend on the observed event numbers. The aim in this research is to use inductive approach which was selected after the collection of the primary data. It is done by doing informal conversation with staff and management of the company.

Intention of the Interview

It is an essential differentiator. The information is flown from the intended direction for the researcher. Differentiation is done in regard to the survey, where the interviewee is the carrier who retrieves information. Other intermediary interviews have respondents who are targeted for information. In some cases, information flow is not from the respondent who is the subject, but the interviewer intention is to start a realization. It is also sometimes consciousness on the respondent's part.

Standardization

The other dimension for the classification reviews is the stage of standardization. It is a constitutive distinction between quantitative and qualitative types of investigation, and in the later section on normalized interview this is explained in detail. Context it only to the detail that a technical review can be conveyed flawlessly in the pattern of everyday connection, with inquiries, and responses are interdependent and a more or less symmetrical dialogue is recorded.

The Standardized Interview

This method is generally utilized in the last phases of an inquiry in which quantitative estimation of applicable matters is being targeted. Characteristic of the normalized interview is that the wording of the inquiries, their sequence, and the likely responses, and the interviewer demeanor are well defined. By normalizing a significance, equivalence of the meetings will be conceived which makes it likely to contrast the facts and numbers with each other. Particularly important steps ahead in normalized reviews the asymmetric connection structure that forces the interviewer to the interviewee, for demonstration, on demand, to talk about, but to reply with the identical granted question. The cause for this is to leverage the interviewees not suggestive. This pattern of the interview is very asymmetric, therefore eliminating its outside pattern most of everyday conversation.

The benefit of this set about that is assembled inside a very short time due to the powerful structuring of the considerations of facts and numbers that can, and these are then in evaluation with each other. The benefit is opposite, will be lost by the currently established answers may deliver supplemental data, and it needs in deepness interview.

The Semi-Standardized Interview

This model of interview is used mainly in research or identifying details of the schemes of the respondents listed at the beginning of an investigation. In this set around, only a record of consultations and direct interviews, which convey a structured conversation? On fixed points allows the interviewer to change the wording of the investigations into the further investigation, or cut more if something was not understood.

As the interviewee gets more space for their formulation, it becomes an advantage. Therefore, the interview proceeds semi-standard in more depth than the benchmark, and can be diverted from the interview guide fixed.

The Unstructured Interview

The unstructured interview aspires to proceed to the very wideness and deepness, so it is furthermore renowned as deepness or intensive interview. Here the interviewer is methodical - if any - only a consideration direct is accessible, a noted interview in which the goal assemblies and probably some of the matters publicity hoc formulated questions. It is generally a very free but controlled the course of consideration, so its form is alike to most everyday conversation.

A benefit of this set about is that much data and minutia information can be gained. Thus, the rationales behind the significance of structuring declarations of interviewees are apparently visible. The handicap is that the facts and numbers got in distinct intensive meetings are not normalized, and thus furthermore will not compare.

For the qualitative empirical communal study as a review procedure was chosen mostly the set about of the meetings founded on an interview guide. The producing there from are in qualitative interview is such a plethora of modifications, which may be discovered, no lone definition. Therefore, in this work, where after the presentation of the essential building for qualitative meetings, a qualitative review of only a couple of has chosen kinds of surveys. For all these reviews is that while the noted data is unbiased authentic, inter subjectively comprehensible and can be duplicated are what demonstration data from participant fact is not the case.

Particularly the likely assessments of the noted meetings with the deductions drawn interpretations give the interview a high-quality methodological and methodological status. In this context it is furthermore significant to take the condemnation to be advised, which is performed in diverse kinds of surveys.

Research Validity and Reliability

Working with quantitative and qualitative methodologies is common. Studies based on interviews are carried out while doing community practice surveys. The committee had a chance to review the questions in APPENDIX A and APPENDIX B as a panel for the validity. For the reliability, I used the literature review. In 1997, the Center for Quality of Management (CQM) described the benefits of reducing cycle time as: 1) Reducing cycle time pleases customers;

customers like immediate responses to their needs. And 2) with reduced cycle times, manufacturers are better able to quickly introduce new products and services, in order to compete with other companies (Imai, 1986). Organizations strive to reduce costs and lead times while maintaining the highest quality. Since lean and the associated kaizen events aim to reduce waste, which leads to cost reductions, organizations can apply these philosophies to achieve the goals of world-class organizations (Hawkins, 1999). Overproduction waste occurs when production takes place earlier than is required by the next process (Dailey, 2005). The next process is any step in the value stream, including the customer. Waiting waste refers to the idle time of employees or equipment as they wait for the arrival of parts from the previous step in the process. Transportation waste refers to the excessive transportation of material, information, or parts through the facility. This category of waste occurs when steps of a process are located distant from each other when they could be located in or near the same area (Alukal & Manos, 2006).

The interview analysis and questions that are open-ended are of great benefit. They show the complex perception of the respondent and are better to bear. Such types of studies also have some disadvantages. One hundred surveys were conducted, and they took a great amount of time. Therefore, it is only suitable for a small sample size. A nationwide study will help to explore and will include thousands of people for confirmation. It can only be achieved through coordination. It should be understood that validity for such questions should not be underestimated. This methodology is often used by social science. The studies that are the preliminary test of our study showed and confirmed that respondents are comfortable and happy. They were ready to complete the questionnaire.

CHAPTER IV

FINDINGS AND DISCUSSION

Qualitative (Interviews with Managers)

The research exercise employed the interview method with questionnaires (Appendix B) which were filled out by the researcher. The main objective was to analyze waste management and decreasing lead time in a medium sized manufacturing company. The questionnaire was composed of open ended questions which addressed the key areas of communication, current work issues, training, and other challenges in the working environment, and the possible solutions to the prevailing issues. The managers were trained and equipped with the necessary information regarding lean terminologies, applications, techniques, and team dynamics.

Data Analysis

After all the interviews were done, a thorough check was performed for each completed questionnaire. This was done to check for missing data, and factual gaps in the responses received from the participants. After coding the questions, data from the completed questionnaires was critically analyzed. Responses to each particular question were examined and devised into categories. This data was then coded and interesting responses from the respondents were quoted in the report.

All the responses in the questionnaires were entered into the database, and enough time was spent cleaning the data to identify inconsistencies and outliers. Frequency figures were also produced for each question. This helped to identify the outliers. Cross tabulation was also done to identify nonsensical responses.

Data Coding

Thirteen identical questionnaires with 28 questions each were filled by different members of the management. Data from the questionnaires was coded as shown below;

Question 1: 70% responded that there is work flow process that concerns them directly in their current roles and responsibilities.

Question 2: 100% of the interviewed managers responded that they have other responsibilities and roles in addition to their first role and responsibility.

Question 5: in response to whether there was some form of training in executing both primary and secondary responsibilities and roles, 100% acknowledged to have been trained, although 30% claimed that the training was not adequate, especially in secondary responsibilities, and it was mostly through observing others perform the tasks that they were able to perform on the same.

Question 6: 90% accepted that staff training is done both locally and from external resources.

Question 7: 95% of the respondents confirmed that they are in contact with other workers or units during their normal operations.

Question 8: 100% confirmed that email and phone are the most used modes of communication; 80% further included meetings and face-to-face communication.

Question 9: 100% confirmed that there are loopholes and issues encountered in the course of their work. The most highlighted issues are failure of the suppliers to deliver in time, lack of timely communication, compromise on accuracy, human errors, and power outages.

Question 10: 100% were positive that there can be improvement on the issues mentioned in Question 9.

Question 11: In an overwhelming response on question 10, several ideas were suggested including holding meetings with the suppliers, improvement, having defined procedures, and level loading supplies.

Question 12: 85% suggested forgetting transaction procedures as the most frequent error in the company.

Question 13: 100% accepted that there is an annual appraisal in the company.

Question 21: 95% reported that failure and disappointment is handled positively in their respective companies.

Question 22: 100% confirmed that they were comfortable in communication with their superiors, and they were positive on the management of their company.

Question 24: 80% of the interviewed were aware of their company's culture, 20% left the question blank.

Question 25: 90% of the interviewed felt that there is need for change in the current structure and mode of operation, with 95% confirming that they would individually embrace new ideas.

Question 27: 92% were skeptical on supporting structural change in their respective companies.

Question 28: 100% of the participants were interested in being part of change in the team.

The data analyzed and coded above was obtained from 13 interviews carried out with different members of the same company. These analyses were entered into the computer database and used to formulate the results and conclusions.

Research Question 1 Managers

For research question one, most of the managers interviewed are directly linked to the manufacturing process. The managers' experiences with the employees especially in the training sessions were found to be challenging in the working group. Commitment to the company's initiatives is very fundamental in any company's success. The managers' responses indicated that constant reviews should be placed to ensure that the objectives of the company are met. The reviews should be in line with the organization's vision and missions. Communication channels should be placed to ensure that the status of projects is well-known to all employees, subsequently leading to improvements and prevention of conflicts in the organization.

Research Question 2 Managers

Senior managers understood that the application of lean manufacturing and other methods would introduce greater flexibility and refocus the organization on activities that would add value to the customer. They realized that these efforts would improve the organization's efficiency and competitiveness and that these would improve overall company process.

The Results of Interview

The results of interview with managers are summarized.

From the analysis of the interviews, it was evident that the managers were inclined to new technologies that will improve the process of waste removal through reducing setup times, improved quality, rationalizing of the supplier base, and reducing paper inventories. These methods act to reduce diseconomies that arise from multiple products sharing constrained resources. Thus plants are better able to manufacture a larger number of products under these systems.

Further, the managers' views on their advocacy for change. After the analysis, the results from the respondents indicated that there was need for quality improvements leading to subsequent reduction in machine malfunctions that generate defective output. For the company to experience greater product variety, some respondents indicated that there should be substantial channeling of resources, especially time towards the activities that will significantly reduce potential losses. Rework increases with batch size and improving quality allows the manufacturers to produce larger batches that are needed for wider product lines. Flexible technology subsequently reduces related costs leading to production of higher quality products.

The responses offered by the managers on the issue of commonly made errors in the workplace included time limits on research and development. This has projected has led to inefficiency and wastage of resources at the workplace. On recommendations on solving the challenge, one respondent suggested that review of work progress be formative and continuously. Another sphere of managers reported unrecorded transactions and lack of standardized procedures in the systems and working mechanisms. In addition, other problems attained from the responses included lack of information accuracy and auditing challenges.

Lack of cooperation among employees was also identified as a major challenge by the managers. Team leaders and employees are given job training specifications with expectations for tremendous results. In the study for instance, work groups at the workplace are involved in processing of batch production, delivery and management failure in any of the work process ultimately ripples into greater problems in service delivery. The managers' experiences with the employees especially in the training sessions were found to be challenging in the working group. By using actual manufacturing process in the simulation, employees identified excess product carrier movements as a waste. The simulation determined that eliminating the excess carrier movements would eliminate waste of motion, over processing, and inventory in various staging areas.

Commitment to the company's initiatives is very fundamental in any company's success. The managers' responses indicated that constant reviews should be placed to ensure that the objectives of the company are met. The reviews should be in line with the organization's vision and missions. Communication channels should be placed to ensure that the status of projects is well-known to all employees, subsequently leading to improvements and prevention of conflicts in the organization.

Quantitative (Results of Questionnaire with Employees)

The results of the questionnaire are given below and the tables of the respective tests are given in the Appendix A.

Question 1: What is your opinion of the waste produced by operations in your company?

Question 2: What is your opinion about the lead time at your place?

Table 1

Correlation (Waste and lead time)

		Q1	Q2
Q1	Pearson Correlation	1	-.114
	Sig. (2-tailed)		.259
	N	100	100
Q2	Pearson Correlation	-.114	1
	Sig. (2-tailed)	.259	
	N	100	100

As seen in the Table 1 the value of the coefficient correlation in question 1 and question 2 is -.114, which means it is negatively related. The correlation is not significant, and the two variables are not linearly related ($p > 0.05$).

Question 1: What is your opinion of the waste produced by operations in your company?

Question A6: Rate your satisfaction level with the following at your company on a scale of 1 to 5 (1 being the most satisfied, 5 being the least satisfied) in terms of: Compensation

Table 2

Correlation (Waste and compensation)

		Q1	A6
Q1	Pearson Correlation	1	.320
	Sig. (2-tailed)		.001
	N	100	100
A6	Pearson Correlation	.320	1
	Sig. (2-tailed)	.001	
	N	100	100

As seen in the Table 2 the value of the coefficient correlation in question 1 and question A6 is .320, which means it is positively related. The correlation is significant, and the two variables are linearly related ($p < 0.05$).

Question 1: What is your opinion of the waste produced by operations in your company?

Question B6: Rate your satisfaction level with the following at your company on a scale of 1 to 5 (1 being the most satisfied, 5 being the least satisfied) in terms of: Overall processes

Table 3

Correlation (Waste and overall processes)

		Q1	B6
Q1	Pearson Correlation	1	-.133
	Sig. (2-tailed)		.187
	N	100	100
B6	Pearson Correlation	-.133	1
	Sig. (2-tailed)	.187	
	N	100	100

As seen in the Table 3 shows that coefficient correlation is -.133, which means it is negatively related. The correlation is not significant, and the two variables are not linearly related ($p > 0.05$).

Question 1: What is your opinion of the waste produced by operations in your company?

Question C6: Rate your satisfaction level with the following at your company on a scale of 1 to 5 (1 being the most satisfied, 5 being the least satisfied) in terms of: Overall management

Table 4

Correlation (Waste and overall management)

		Q1	C6
Q1	Pearson Correlation	1	.156
	Sig. (2-tailed)		.121
	N	100	100
C6	Pearson Correlation	.156	1
	Sig. (2-tailed)	.121	
	N	100	100

As seen in the Table 4 the value of the coefficient correlation is .156, which means it is positively related. The correlation is not significant, and the two variables are not linearly related ($p > 0.05$).

Question 1: What is your opinion of the waste produced by operations in your company?

Question D6: Rate your satisfaction level with the following at your company on a scale of 1 to 5 (1 being the most satisfied, 5 being the least satisfied) in terms of: Work environment

Table 5

Correlation (Waste and work environment)

		Q1	D6
Q1	Pearson Correlation	1	.390
	Sig. (2-tailed)		.000
	N	100	100
D6	Pearson Correlation	.390	1
	Sig. (2-tailed)	.000	
	N	100	100

As seen in the Table 5 the value of the coefficient correlation is 390, which means it is negatively related. The correlation is significant, and the two variables are linearly related ($p < 0.05$).

Question 2: What is your opinion about the lead time at your place?

Question A6: Rate your satisfaction level with the following at your company on a scale of 1 to 5 (1 being the most satisfied, 5 being the least satisfied) in terms of: Compensation

Table 6

Correlation (Lead time and compensation)

		Q2	A6
Q2	Pearson Correlation	1	-.098
	Sig. (2-tailed)		.330
	N	100	100
A6	Pearson Correlation	-.098	1
	Sig. (2-tailed)	.330	
	N	100	100

As seen in the Table 6, it can be seen that the value of the coefficient is -0.98, which means it is negatively related. The correlation is not significant, and the two variables are not linearly related ($p > 0.05$).

Question 2: What is your opinion about the lead time at your place?

Question B6: Rate your satisfaction level with the following at your company on a scale of 1 to 5 (1 being the most satisfied, 5 being the least satisfied) in terms of: Overall management

Table 7

Correlation (Lead time and overall processes)

		Q2	B6
Q2	Pearson Correlation	1	.079
	Sig. (2-tailed)		.437
	N	100	100
B6	Pearson Correlation	.079	1
	Sig. (2-tailed)	.437	
	N	100	100

As seen in the Table 7, it can be seen that the value of the coefficient correlation is 0.79, which means it is positively related. The correlation is not significant, and the two variables are not linearly related ($p > 0.05$).

Question 2: What is your opinion about the lead time at your place?

Question C6: Rate your satisfaction level with the following at your company on a scale of 1 to 5 (1 being the most satisfied, 5 being the least satisfied) in terms of: Overall management

Table 8

Correlation (Lead time and overall management)

		Q2	C6
Q2	Pearson Correlation	1	-.203
	Sig. (2-tailed)		.043
	N	100	100
C6	Pearson Correlation	-.203	1
	Sig. (2-tailed)	.043	
	N	100	100

As seen in the Table 8, it can be seen that the value of the coefficient correlation is -.203 1, which means it is negatively related. The correlation is not significant, and the two variables are not linearly related ($p > 0.05$).

Table 9

Descriptive Statistics (Question 1 and Question 2)

	Mean	Std. Deviation	N
Q1	3.90	.716	100
Q2	3.96	.788	100

The mean for question 1 and question 2 was 3.90 and 3.96 on the 5-point scale which show the average choice of the respondents.

Table 10

Descriptive Statistics (Question 1 and Question A6)

	Mean	Std. Deviation	N
Q1	3.90	.716	100
A6	2.94	.941	100

The mean for question 1 and question A6 is 3.90 and 2.94 on the 5-point scale which show the average choice of the respondents.

Table 11

Descriptive Statistics (Question 1 and Question B6)

	Mean	Std. Deviation	N
Q1	3.90	.716	100
B6	3.21	.624	100

The mean for question 1 and question B6 shows that average selection is 3.90 for question 1 and 3.21 for question B6 on the 5-point scale which show the average choice of the respondents.

Table 12

Descriptive Statistics (Question 1 and Question C6)

	Mean	Std. Deviation	N
Q1	3.90	.716	100
C6	2.64	.847	100

The mean for question 1 and question A6 shows that average selection is 3.90 for question 1 and 2.64 for question C6 on the 5-point scale which show the average choice of the respondents.

Table 13

Descriptive Statistics (Question 1and Question D6)

	Mean	Std. Deviation	N
Q1	3.90	.716	100
D6	3.01	1.124	100

The mean for question 1 and question D6 shows that average selection is 3.90 for question 1 and 3.01 for question D6 on the 5-point scale which show the average choice of the respondents.

Table 14

Descriptive Statistics (Question 2 and Question A6)

	Mean	Std. Deviation	N
Q2	3.96	.788	100
A6	2.94	.941	100

The mean for question 2 and question A6 shows that average selection is 3.96 for question 2 and 2.94 for question C6 on the 5-point scale which show the average choice of the respondents.

Table 15

Descriptive Statistics (Question 2 and Question B6)

	Mean	Std. Deviation	N
Q2	3.96	.788	100
B6	3.21	.624	100

The mean for question 2 and question B6 shows that average selection is 3.96 for question 2 and 3.21 for question B6 on the 5-point scale which show the average choice of the respondents.

Table 16

Descriptive Statistics (Question 2 and Question C6)

	Mean	Std. Deviation	N
Q2	3.96	.788	100
C6	2.64	.847	100

The mean for question 2 and question C6 shows that average selection is 3.96 for question 2 and 2.64 for question C6 on the 5-point scale which show the average choice of the respondents.

Hence it can be seen that employee satisfaction is not related to lead time reduction. Similarly, employee satisfaction is also not related to waste reduction.

CHAPTER V

CONCLUSION

Following are the summary, conclusions, and recommendations drawn from the complete process of developing this research, from the conception of the topic, formulation of the methodology, data gathering, calculation, and analysis of results.

Summary

This study shows that how lean manufacturing system and waste minimization are complementary and synergistic. Researchers should evaluate their current practices, and lean and green practices, to emphasize complementary and synergistic options, while they search for alternatives to the conflicting practices that interfere with the objectives of the system. Professionals at the strategic level should focus on the integration of management systems Lean and Green. Production executives must have a close look at its policy statements, metrics / objectives, resource allocation, training, process management review, and so forth, and begin to integrate them.

Conclusions

The Waste Minimization initiative is achievable using existing resources and the same basic manufacturing methodology. It just requires a paradigm shift in the way manufacturing processes are currently planned.

Implementing lean and other mentioned methods requires a change in thinking and culture as well as a change in processes. Management must be committed to the change, must train everyone to the new culture, must ensure the organization's culture fosters employee participation, and must monitor results over time. One method of fostering participation is the establishment of suggestion systems where management considers all suggestions and rewards employees for their contributions. Without management commitment, employees will view kaizen and lean as a management fad and will not participate fully in the culture change.

Extended studies of JIT manufacturing have relied on anecdotal evidence and case studies to examine the implementations among manufacturers. The studies that research the organizational and strategic implications on performance find that there are significant differences between the manufacturers. They attribute much of these to differences in labour relations, financing costs, and vendor partnerships. Traditionally, manufacturers have relied on integration as a means to achieve vertical control. Facing new technologies that provide such control without the burden of ownership, they are now learning to cope.

. The benefits of this study will be realized by plants and depends on the inherent flexibility that they have which depends on their relative position in the value chain. There is also some evidence that JIT diffuses from downstream plants to their upstream suppliers. The incentives created for a supplier by the manufacturer adopting JIT need to be investigated.

The interview with managers gave us the following suggestions.

- Training all employees, including senior managers, on lean principles
- Aligning lean initiatives with the organization's vision
- Frequently communicating the purpose and status of the lean initiatives with all employees; and
- Ensuring employees that the goal of lean is to make improvements, not to decrease the number of employees.

Recommendations

Based on the study the following is a list of recommendations to start a Waste Minimization initiative during the planning stage of a manufacturing system.

1. When presenting the WM initiative to people responsible for a manufacturing system, they must understand that there is absolutely nothing wrong with the system they are currently using; it is a paradigm shift that needs to be introduced in order to help the system produce less waste. Industrial waste may become harmful to the environment. Presenting the initiative like that may help minimize resistance to change.
2. The new paradigm must have management support in order to succeed. The manufacturing scheduling and sequencing discipline may contribute positively to accomplish this task.
3. Train the appropriate personnel.
4. Place an information board to share with everybody the amount of waste avoided during a given week. Keep comparative charts.
5. Include in the quality policy of the organization a point regarding waste minimization.

As Organization element, the plant still has room for Lean manufacturing principles. The Pull Production System is the first subject that the company needs to reconsider. There are still many non-working parts, units, and machines on the floor. Production still needs to establish physical distribution in the plant. An ideal of Pull Production system is to pass necessary parts or machine units on time to next area. Lacking and remaining parts cause waste in the plant.

The second consideration is inventory. In inventory, machine parts are supplied by modular kits. Those kits are identified by a computer system which calculates the number of parts and units necessary. The inventory area, then, supplies them to each area. In this process, the bigger inventory the plant has, the longer time it takes to provide the lacking or necessary parts. The plant should minimize open finished inventory.

The third, "Modular purchasing," is a method in which the company would purchase machine parts as units from outside vendors, instead of buying and assembling all the parts itself. The researcher believes that implementing this concept would continue the process of eliminating unnecessary work, simplifying the assembly process, and reducing costs. The last suggestion is to integrate a modular assembly information system (Information Technology) to all areas in the plant assembled by workers to be placed in appropriate areas so that workers need to move as little as possible. In other words, studying ergonomics and creating appropriate locations for all parts, parts units, and tools that are always set near workers. Secondly, operation height is also a very important ergonomic consideration. The height needs to be considered based on human engineering. This would considerably affect workers' efficiency. Lastly, workers need to use electrical pneumatic tools. A few workers still tend to use conventional tools because they are familiar with them. Power tools would be more efficient.

The last "Kaizen" element for Modular assembly manufacturing is to promote the pull system approach of Lean Manufacturing. The researcher has suggested incorporating an IT system, such as Enterprise post office data conversion system (EPOC). The Dynamic element is to improve workstations environment in the plant. Integration of that software would enhance technical communication across not only the factory floor but also sales department in real time. EPOC enable sales department to seamlessly communicate information of incoming orders to the production department by electronic mail. The software calculates option parts based on the customer's order. The advantage of EPOC is that:

- Reduction of lead-time from order to parts arrangement
- Reduction of production lead-time through acquiring customer order information in real time.
- Prompt correspondence by intensification of cooperation between systems in all departments.

- Save writing papers, sending fax, re-entering and checking data by electrical information system.
- Prevent human mistakes.
- Share of information.

Electronic Data Interchange (EDI) would enhance manufacturing productivity added to EPOC system. EDI enables outsourcing to vendors by electrical order instead of mailing a purchase order sheet. The vendors automatically receive from EDI server and then identify the ordering parts. Production also can monitor confirmation including

- Reduction of lead-time for parts order.
- Prevention of parts lacking and acquirement of beforehand information by electrical delivery control
- Accurate out-sourcing control by monitoring progress report for delivery and delay information
- Faster correspondence would be possible by receiving early information.

Other factors to be considered in future studies are:

- Impact of proper manpower on reducing cycle time
- Relationship between fixed cost reduction and cycle time reduction inventory adjustment

<u>Recommended Future Research</u>

Industry offers a great opportunity for further research related to the present study. Longitudinal studies across various industries could be performed in order to gauge the benefit of waste minimization/pollution prevention with three specific goals.

1. Validate the effectiveness of the manufacturing scheduling and sequencing tool across a variety of industries that generate a variety of different wastes.

2. Identify and categorize the different types of hazardous and non-hazardous waste streams across different types of industries, which can be minimized or eliminated using the new manufacturing scheduling and sequencing paradigm.
3. Measure the global impact of the minimization of waste from a manufacturing scheduling and sequencing perspective. Perform a concomitant cost-benefit analysis that can then be used by EPA and others to formulate policy.

Additionally, less extensive research projects may also be set. The most natural research in this area will be the use and introduction of an optimization neural network to the scheduling floor and compare it to the current methodology. Find outfit adds any value and in what terms (time, accuracy, user-friendliness). The neural network could be expanded to include information on maintenance conditions of machinery, on-hand inventory of raw materials for any given week, so that in case of subtle change the scheduling may be adapted promptly. In other words, to be able to re-schedule into fewer machines the volume that was originally scheduled to be produced with all the machinery available. The planning tool could be enhanced to work from a Visual Basic application so a person with minimum knowledge about computers may easily use it.

A detailed cost analysis to determine the savings obtained by minimizing the waste could also be explored. This cost analysis could be used as a tool to motivate currently reluctant manufacturing managers to implement the Waste Minimization initiative. Two additional factors could be studied: lead-time and work in process. The first could be used to determine how critical it may be to have a machine with a slightly longer set-up time. Weekly, daily and hourly manufacturing levels could be used to investigate to what level delivery may be affected by the waste minimization strategy. The work in process factor may help to visualize the optimal range of the load size looking from the cost-benefit perspective. Final recommendation, the Waste Minimization paradigm shift starts when a factor that represents the minimization of waste is given the same importance as all other factors in the manufacturing process, such as throughout and manufacturing capacity.

Value Stream Mapping

To make improvements, it is critical to know the current state of the company, to understand where it desires to be, and to determine how it will get there. Employees document these decisions and actions on a value stream map. The worth stream chart is a design drawing of every step that material and data take along the worth stream from merchandise beginning to consignment to the customer.

Detailed step-by-step directions on conceiving a worth stream chart utilizing normalized periods and icons is beyond the scope of this thesis. Among other causes, it presents a demonstration of conceiving a worth stream map. General guidelines to mapping the worth stream are:

- Form a cross-functional worth stream team.
- Train group constituents how to chart the worth stream and how to recognize waste.
- Observe all methods along the worth stream. Observations throughout the busiest time of day and throughout diverse moves assists in double-checking the method and can rendezvous clientele demand and assist in recognizing best practices.
- Diagram all of the method undertakings and data moves on the worth stream map.
- Identify the number of personnel, the amount of material, the duration of process steps, and the duration between process steps for each step on the value stream map.
- Calculate the value-added and non-value supplemented undertaking times all through the process.

- Create a future-state map keeping customer value and take time in mind. For medical manufacturing organizations, customer value includes adherence to regulatory requirements.
- Standardize the improvements and continue to seek opportunities for additional improvement.
- Establish metrics by which the organization will measure lean success.

This organization realized the importance of value stream mapping; the resources reviewed for this thesis describe their efforts in detail. Although the organizations conducted mapping for each value stream, discussion of only one value stream map from each organization is included in this thesis. A summary of the application of value stream mapping at these organizations helps the reader understand the use of this tool.

The new technologies attempt to remove waste through reducing setup times, improving quality, rationalizing the supplier base, and reducing inventories. These methods act to reduce dis-economies that arise from multiple products sharing constrained resources. Thus, plants are better able to manufacture a larger number of products under these systems. This chapter describes the impact of setup time reduction and quality improvements on a manufacturer's choice of product variety. The model described in this work consists of a manufacturing facility that supplies a product in market consisting of consumers with heterogeneous tastes.

The production stage consists of a single resource which is used to manufacture multiple products. The monopolist manufacturer chooses the number of products and the quantity to supply a market consisting of heterogeneous consumers. It is shown that setup time reduction enables the manufacturer to offer greater variety due to a reduction in the dis-economies of scope, in terms of changeover costs. The batch sizes of each product are smaller due to two separate effects, shorter setups, and product capitalization. Moreover, by offering more products the manufacturer is able to charge higher prices and increase revenues even though volume per product declines. This decline in volume further reduces batch sizes.

Quality improvements or reduction in machine malfunctions that generate defective output also lead to greater product variety since defect reduction reduces the amount of rework that is needed. Rework increases with batch size and improving quality allows the manufacturer to produce larger batches that are needed for wider product lines. The monopolist manufacturer is supplied pans by an external parts fabrication facility. The manufacturer's product variety decision influences the demand for parts faced by the supplier through affecting either the volume or the variety of parts demanded.

The supplier, too, faces dis-economies of scope due to setup times in parts fabrication. I study the supplier's incentives to invest in setup reduction, and show that he will reduce setup times only if part variety does not increase with product variety. In fact the supplier strictly prefers higher setup times if part variety increases as the manufacturer offers a wider portfolio in the product market. The costs associated with broader product lines have been the subject of numerous studies.

Limitation of the Study

Some limitations that our research encountered must be included here. These limitations also furnish new areas wherein future research can be conducted. First, the research is restricted to a certain company from which the data is extracted. Additional research may employ cross-culture equivalences. Second, this research would employ data which is accumulated from employees who find it difficult to discuss their views.

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APPENDIX A

QUESTIONNAIRE 2 (FOR EMPLOYEES)

What is your opinion of the waste produced by operations in your company?

- ☐ Very high amount of waste
- ☐ High amount of waste
- ☐ Acceptable amount of waste
- ☐ Low amount of waste
- ☐ Very little waste

What is your opinion about the lead time at your place?

- ☐ Very high amount of lead time
- ☐ High amount of lead time
- ☐ Acceptable amount of lead time
- ☐ Low amount of lead time
- ☐ Very little lead time

Do you think that lead time reduction will help you get more clients?

- ☐ Yes
- ☐ No
- ☐ Others (please specify) ________________

Do you think that waste reduction will help in minimizing production costs?

- ☐ Yes
- ☐ No
- ☐ Others (please specify) ________________

On a scale of 1 to 5, (1 being the best and 5 being the worst) rate your organization in terms of:

Cost effectiveness	
Employee satisfaction	
Productivity maximization	

Rate your satisfaction level with the following at your company on a scale of 1 to 5 (1 being the most satisfied, 5 being the least satisfied) in terms of:

A Compensation	
B Overall processes	
C Overall Management	
D Work environment	

Would you classify your company as:

Customer-oriented ------------------- Product-oriented

Slow to change ------------------- rapidly adopting change

Technologically fit ------------------- Technologically unfit

Constantly investing in improving processes ------------------- no investments in improvement

Please suggest three ways in which you think your organization can reduce waste

____

Please suggest three ways in which you think your organization can reduce lead time

____

Thank you for your time!

APPENDIX B

QUESTIONNAIRE 1 (FOR MANAGERS)

The interviews will have open questions administered to employees and managements and for the duration of 30 minutes each at their place of work for one week.

(A) Interview Structure

The interviewer schedules will divide the interview in to an introduction which will include the interview's formality, highlight objectives of study, state the purpose of the interview, give a guarantee on confidentiality of the information being given, start the interview and conclude it and finally appreciate the Participant.

(B) Typical Questions

The following questions are asked in the interview.

Preamble

Good morning/ afternoon (depending with the time of the interview). I am a student carrying out study about an analysis of managing waste and decreasing lead time in a medium manufacturing company. Information provided will be held in utmost confidential, thus, feel free to answer the question posted. This interview will take utmost 25 minutes to conclude, and I will highly appreciate your vital spared time in answering these simple questions. The information given will not be used for other purposes apart from academic.

1. In your current role and responsibilities is there any work flow process that concerns you directly?

....

2. Apart from the first role and responsibility, do you have other responsibilities and roles? Name them.. ....
....

3. Was there any provided training to execute both the primary and secondary responsibilities and roles? ....

4. Was the training done locally; that is, within the organization or from external resource?

5. Please, mention the other workers or unit most regularly in contact with when performing their duties?

....

....

6. In your current working setting, what mode of communication is adopted?

....

7. According your views do they think there can be improvement?

....

....

8. If Yes in question 10, any ideas on improvement? ....

....

9. Do you as individually embrace new ideas? Provide reasons for your answer

....

....

10. Should there be future plans towards having a changed structure, will you support it and why?..

....

Thanks very much for participating in this research. I strongly believe that your vital information will be significant in managing waste and decreasing lead time in a medium manufacturing company. Once again thank you for your time and consideration