THE INTRODUCTION OF LEAN MANUFACTURING IN A SELECTED SOUTH AFRICAN ORGANIZATION

By

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In the Faculty of Commerce

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14 April 2008

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RE: Permission for Submission

This research project has been reviewed by the undersigned and hereby permission is granted for submission for examination.

Sincerely,

Mrs. M. Lourens

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This work is of strategic importance.

It would be appreciated if the contents of this dissertation remain confidential and not be circulated for a period of five years.

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ABSTRACT

The aim of this research is to analyze the introduction of lean manufacturing in a selected South African organization viz. Smiths Manufacturing. The research, together with its conclusions, may identify problematic areas which, once addressed, will improve the implementation in other areas and identify the benefits, if any, of lean manufacturing.

Three research objectives exist and two methods of research were used to solve the research questions. The first and second research objectives (i.e. to analyze the manner in which lean manufacturing was introduced in Smiths Manufacturing and its benefit on the company's competitive position and future existence) were analyzed qualitatively with the aid of personal interviews. The third research objective (i.e. to determine the financial benefit of lean manufacturing introduction on the respective assembly line) was analyzed quantitatively.

This research revealed three pertinent findings: Firstly, Smiths Manufacturing has adhered to eight of Liker's 13 Step Implementation Procedure with two areas of non-conformance being identified and insufficient information present to comment on the remaining three steps.

Secondly, improvements in the manufacturing process have enabled the company to be more price competitive. Areas of improvement were in labour, raw materials and finished goods. These improvements will assist in ensuring the company's future existence.

Thirdly, there has been a substantial amount of savings by the introduction of lean manufacturing.

This research has identified that communication involving lean manufacturing is vital to introducing a system into a company. This communication enables people at all levels to understand the roll out procedure and the corresponding actions of the company. In addition, the research revealed that the

implementation of lean manufacturing improves manufacturing processes, which result in financial gain to the company. This improvement in the assembly processes helps reduce costs associated with manufacture of the assembly, which aids the company in competing. Being competitive is vital to the future existence of companies competing in a global arena.

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LIST OF ABBREVIATIONS

CBU:	Central Business Unit
CKD:	Control Knock Down
EBIT:	Earnings before Interest and Tax
5S:	Five Systems i.e. sifting, sorting, sweeping, spick and span and safety
HVAC:	Heating Ventilating Air-conditioning Unit
JIT:	Just In Time
MIDP:	Motor Industry Development Programme
OEM:	Original Equipment Manufacturer
TIE:	Total Industrial Engineering
TPM:	Total Productive Maintenance
TPS:	Toyota Production System

GLOSSARY OF TERMS

Heijunka:	It is a method of smoothing the production schedule thus ensuring that the customers' just in time requirements are met.
Jidoka:	It has two separate meanings i.e. automation and autonomation. Automation refers to changing the process from a manual process to an automated process. The problem with automation is that the process has no way of detecting errors. Hence there is a need for autonomation. Autonomation is an automated process with the ability to detect and correct errors to reduce scrap.
Just in Time (JIT):	This is a repetitive manufacturing system in which the production and movement of parts occur just as they are needed in small batches.
Kaizen:	It is a continuous improvement process throughout the manufacturing procedure as per customer needs.

Lean Manufacturing: It is the process of eliminating waste or non-value added tasks in a manufacturing process through continuous improvement.

Toyota Production System (TPS): TPS is Toyota's term for lean manufacturing.

Standardised Work: This is a documented standard for performing tasks that focuses on both man and machine.

CHAPTER ONE

OVERVIEW OF STUDY

1.1 INTRODUCTION

Markets are changing as suppliers and consumers become global in nature (Hill, 2003:4). Globalization refers to the interdependency of transportation, distribution, communication and economic networks across international borders (Gibson, Ivancevich and Donnelly, 1994:53). According to Frankel, as cited in Hill (2003:8), globalization is due to a decline in trade barriers to the free flow of goods. Technological improvements in communication, information processing and transportation have further aided globalization.

The globalization of production allows goods to be sourced from around the world. Globalization affects all industries with focus being on the motor industry. The South African Motor industry has been protected from globalization by the Motor Industry Development Program (MIDP). The MIDP serves two purposes, viz., to make the local industry globally competitive and to balance the import-export account by a system of tariffs and rebates (Seldon, Undated:1).

Tariffs are imposed on imported automotive components, which can be offset by exporting the equivalent value of motor vehicle components or vehicles. The South African motor industry is presently protected by tariffs of 34 percent for central business units (CBU's) and 27 percent for imported parts {referred to as control knock down (CKD)}. These tariffs reduce to 25 percent for

CBU's and 20 percent for CKD parts by 2012. The reductions in tariffs result in less protection for local manufacturers who now have to be just as competitive on pricing as their global competitors. The tariffs for CBU's and CKD's for 2002 to 2006 are indicated in Table 1.1.

Table 1-1: Yearly Tariffs

YEAR	CBU TARIFF (%)	CKD TARIFF (%)
2002	40	30
2003	38	29
2004	36	28
2005	34	27
2006	32	26

Source: Seldon, Undated:1

Tariff reductions allow local customers the benefits of international sourcing. International sourcing allows customers to buy from suppliers who have the lowest price with the desired quality level. International sourcing can result in local businesses closing as South Africa only produces 0.6 percent of the world's vehicle output (Barnes and Deghaye, 2004:5).

International sourcing allows companies to take advantage of national differences in the cost and quality of the product. A cost reduction aids the company in supporting aggressive pricing. This reduction is vital in an environment where there are strong pressures to reduce costs. Cost reduction is one of the competitive pressures that global firms experience. Suppliers, therefore,, need to ensure that their products are cheap and of desirable quality as they are no longer competing in national markets but global markets (Hill, 2003:7; 417; 423).

In order to become more globally competitive, manufacturers have looked at means of improving the manufacturing processes by introducing various systems (Pisano and Hayes, 1995:xiii). These systems are total quality management, process re-engineering, benchmarking and lean manufacturing. The proper introduction of these systems assists local companies in competing in international markets. An incorrect introduction and implementation procedure could, however, cause more harm than good.

1.2 PROBLEM STATEMENT

Smiths Manufacturing, being a global supplier, has introduced lean manufacturing on certain lines in order to improve global competitiveness and decrease costs. The company has failed to convert the implementation of lean manufacturing to a monetary figure and have not analyzed the implementation procedure.

The benefit of lean manufacturing can only be realized once the barriers to successful implementation have been removed. Some of these barriers occur as a result of the failure to convert the implementation to a financial gain or loss and an incorrect implementation procedure (Kilpatrick, 2003:4). A problem, therefore, exists as the company is unaware if lean manufacturing has benefited the organization or if the implementation procedure was correct.

The lack of this data could result in the halt of a potentially good manufacturing system or the incorrect implementation on other production lines in the company. This deficiency could have an adverse effect on the performance of the company. Hence, there is a need for this research/study.

1.3 SUB-OBJECTIVES

The aim of this research is to analyze the introduction of lean manufacturing in Smiths Manufacturing. The research together with its conclusions may identify problematic areas which, once addressed, will improve the implementation in other areas and identify the benefits, if any, of lean manufacturing.

The research will comprise of three sub-objectives, namely:

- To analyze the manner in which lean manufacturing was introduced on one of the assembly lines in Smiths Manufacturing;
- To analyze the financial benefit of lean manufacturing on this assembly line; and
- To analyze the benefit of lean manufacturing introduction to Smiths Manufacturing's competitive position and future existence.

1.4 RESEARCH PROPOSITIONS

The research propositions for the three research objectives are as follows:

- Smiths Manufacturing has not conformed to the recommended steps in implementing lean manufacturing;
- There has been an increase in profits due to the reduction in stock holding of sub-assemblies and finished goods; and
- The introduction of lean manufacturing has increased the competitiveness of the company.

1.5 DE-LIMITATIONS

The limitations with the above-mentioned research design occur as a result of respondents' frame, time and funding.

Respondents are limited to 20 individuals of whom 12 are line workers, four are engineers and four are managers. This size poses problems for focus groups. According to Cooper and Schindler (1998:138), focus groups should have between six to ten people. These figures are important as too few people may result in less member participation. The focus groups, involving the line workers, adheres to this figure but relies on all operators to be present.

The limited number of people also poses problems, as participation by the majority of them is vital for the study to be representative. People participation will be encouraged by them being paid for their time. Financial constraints exist with regards to the payment of participants. Therefore, the duration of interviews will be limited as the research is for academic purposes and has been personally funded.

1.6 MOTIVATION FOR THE PROPOSED RESEARCH

In order to become more competitive, manufacturers have looked at means of improving the manufacturing processes by introducing various systems (Pisano and Hayes, 1995:xiii). These systems are total quality management, process re-engineering, benchmarking and lean manufacturing.

Smiths Manufacturing has introduced lean manufacturing in order to improve its competitiveness. The company, is however, unaware if lean manufacturing has had the desired effect as it has not measured the benefit thereof. According to Kilpatrick (2003:4), the absence of a financial assessment is a barrier to successful lean manufacturing implementation. Another barrier is an incorrect implementation procedure. Smiths Manufacturing is unaware if the implementation procedure is correct as they have failed to review the procedure after its implementation on the assembly line.

The lack of an implementation review may pose problems as the company may be repeating mistakes on other lines, which may be to its detriment. Coupled with the lack of an implementation review, is the lack of a financial analysis as the company is unaware whether the implementation of lean manufacturing is saving money. It is because of the lack of the implementation and financial review that a study of this nature is required.

Research into the introduction and implementation of lean manufacturing will highlight areas of poor performance and suggestions will be made for improvements in other lines. A financial study will also be conducted to convert the implementation of lean manufacturing to a monetary figure. This data will aid in driving the implementation of lean manufacturing as employees will be able to justify the implementation costs against the long-term benefits.

1.7 CHAPTER SUMMARY

The outline for the following chapters is as follows:

- Chapter two will discuss literature relevant to the study. This literature review will include the history of lean manufacturing together with the systems, benefits and limitations that impact on a company's strategy and employees and their effect on the company's financial position. This chapter focuses on both the qualitative and quantitative variables of the problem statement.
- Chapter three identifies and describes the methodology used in the dissertation in order to determine whether a qualitative or quantitative realm will be used. The chapter then focuses on the methodology used for each realm.
- Chapter four is a presentation of the changes on the 558N air-conditioner line before and after the implementation of lean manufacturing and the corresponding financial analysis.
- Chapter five is a presentation of results and analysis from the in-depth personal interviews.
- Chapter six offers an interpretation of the financial results.

- Chapter seven provides the company with conclusions and recommendations based on the findings that were established from chapters five and six.

1.8 CONCLUSION

Chapter two now follows which will provide a review of relevant literature pertaining to the problem statement and research problems identified above in sections 1.2 and 1.3, respectively.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

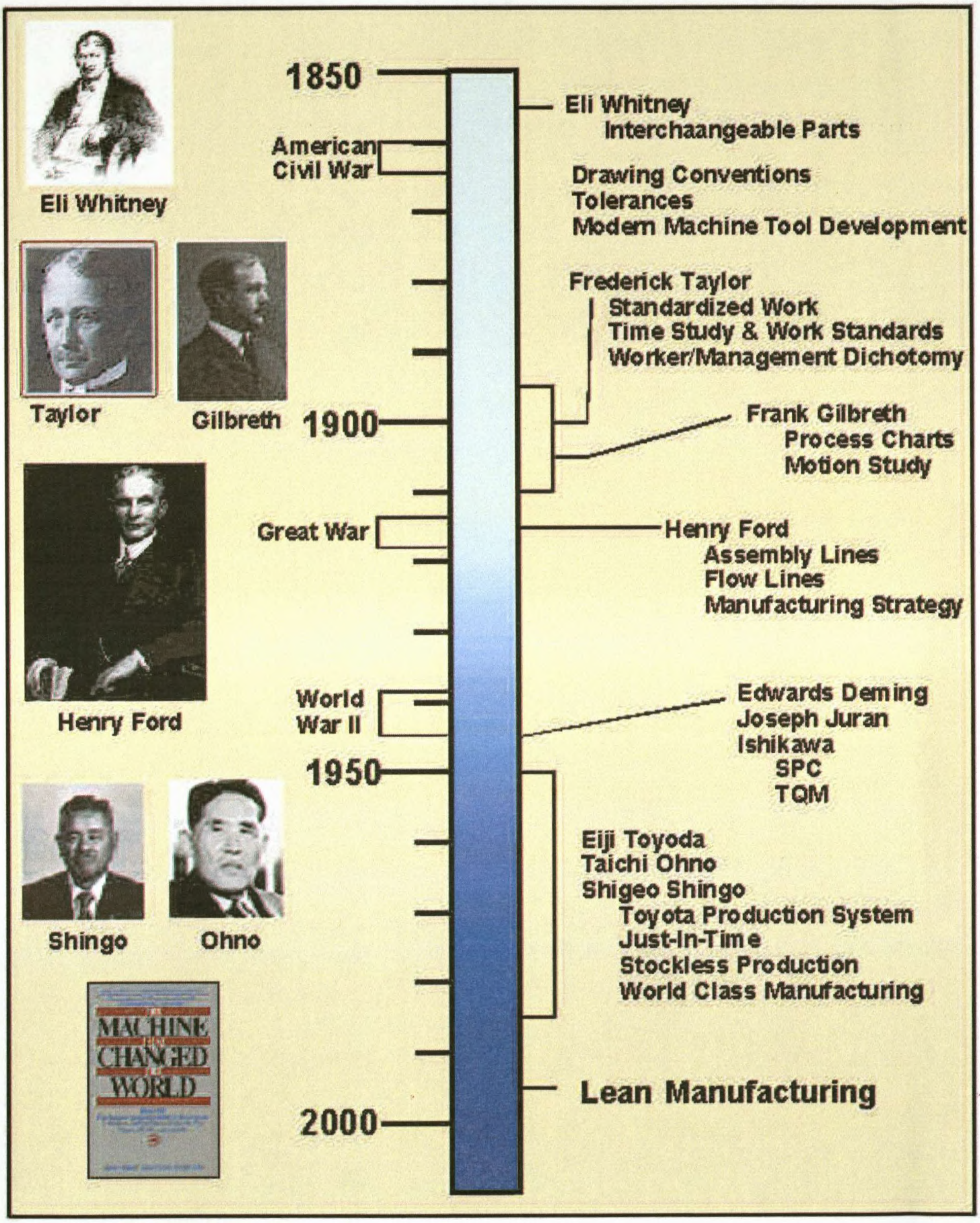
This chapter provides an outline of the history of lean manufacturing coupled with a definition of lean manufacturing, its sub-processes, benefits and limitations of the system and its implementation procedure. Once an understanding of lean manufacturing and its principles have been attained, their effects, on the motor industry will be highlighted.

In conclusion, the reasons for Smiths Manufacturing adopting the system are discussed and an overview of the company is given.

2.2 HISTORY OF LEAN MANUFACTURING

While the concept of lean manufacturing is relatively new, its origin stems back to the 1890's with the work of Eli Whitney and key industrial engineers, viz., Frederick Taylor, Frank Gilbreth and Lillian Gilbreth. The path is shown in **Figure 2-1**.

Figure 2-1: Lean Manufacturing History



Source: Strategos Consultants Engineers and Strategists, Undated:1

Eli Whitney perfected the concept of interchangeable parts in production in 1799. From 1799 to the 1890s manufacturers developed and improved individual technologies while little focus was placed on the process itself. Focus on the process changed in the late 1890s with the work of Frederick Taylor, Frank Gilbreth and Lillian Gilbreth (Strategos Consultants, Engineers and Partners, Undated:1).

Frederick Taylor focused on scientific management, which resulted in the concepts of time study and standardized work. He however, ignored the behaviour of the worker, which was later addressed by Lillian Gilbreth. Frank Gilbreth's work, while not focusing on the behavioural sciences of the worker as addressed by Lillian Gibreth, focused on the worker's movement, which resulted in motion study and process charting. Process charting involved recording all aspects of the process including those that added no value. Both engineers failed to realise that worker attitude must be studied as it impacts the process. The importance of worker attitude was realised by Lillian Gilbreth who studied the motivation of the worker and its affect on the process (Strategos Consultants, Engineers and Partners, Undated:1).

All three engineers are responsible for the idea of eliminating waste which is the cornerstone of lean manufacturing (Strategos Consultants, Engineers and Partners, Undated:1). Henry Ford utilised the work of all three engineers and developed the first comprehensive manufacturing strategy in 1910. The modification of this strategy by Toyota led to lean manufacturing.

According to Womack, Jones and Roos, as cited by Browne, Harhen and Shivnan (1999:76), Toyota started lean manufacturing in the 1950's. Eiji Toyoda had visited the Ford River Rouge plant in an attempt to learn methods of mass production but this method of production was not possible in Japan due to the presence of few auto manufacturers who needed to make a variety of cars in one plant. Further to the limited number of auto manufacturers, was the absence of capital to invest in modern technology as present in the Ford motor plant. This absence of capital and limited number of auto manufacturers prompted Eiji together with his production manager Taiichi Ohno to develop a production system known as the Toyota Production System or lean manufacturing (Nicholas, 1998:13).

Today, lean manufacturing has become the buzzword for cost reduction in a manufacturing environment. It is the buzzword because if all companies produce a functional product, then manufacturers will have to compete on cost, service and quality (Goddard, 1986:6). In order to reduce costs, companies can improve the manufacturing processes by introducing various systems such as lean manufacturing (Pisano and Hayes, 1995:xiii). Lean manufacturing differs from traditional manufacturing by the quantity produced per station. Traditional manufacturing favours batch building of sub-assemblies per station. Lean manufacturing favours one item produced per work station. Hence, there is reduced work in progress (Epply and Nagengast, Undated:2). Lean manufacturing attacks the wasteful areas of the process, which reduces costs, improves quality and services the needs of the customer quicker.

2.3 LEAN MANUFACTURING

2.3.1 DEFINITION: LEAN MANUFACTURING

Lean manufacturing is a systematic way of identifying and removing waste in a process. Waste is regarded as all those aspects that do not add value to the assembly process e.g. unnecessary walking. Following the path of a part from start to finish identifies areas of waste. Wastage is reduced in these areas through a process of continuous improvement (Lean Manufacturing, 2005:1). Other common names for lean manufacturing include World Class Manufacturing, Stockless Production, Continuous Flow Manufacturing, Just-in-time Manufacturing and Toyota Production Systems (TPS) (Strategos Consultants, Engineers and Partners, Undated:2). Lean manufacturing differs from large scale manufacturing by its manufacturing principles or characteristics.

The characteristics of lean manufacturing, according to Jones, as cited by Browne, Harhen and Shivnan (1996:76), are:

- The production of a part is customer-driven as opposed to the need to manufacture volume production;
- All activities are organized and focused on a product line with activities being team based;
- The involvement of fewer production heads;
- The presence of high levels of information exchange and transparency between all members;
- The activities of the entire production chain are linked as opposed to each team functioning separately;

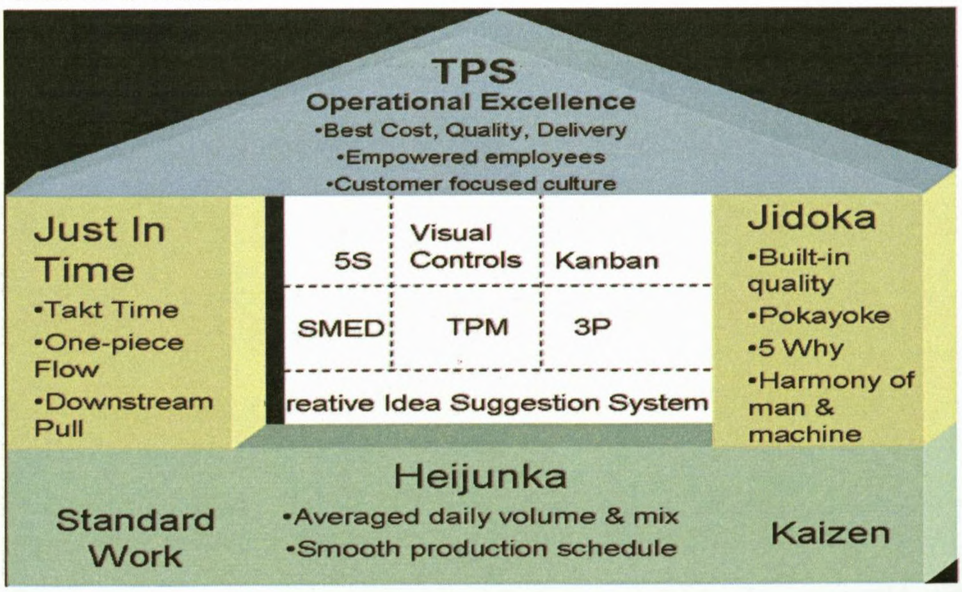
- The sub-systems needed for lean manufacturing to function are just-in-time manufacturing and total quality in the plant and at the supplier;
- Empowering of lower level staff members; and
- The manufacturing system is based on stable production volumes but there must be flexibility.

The functioning of lean manufacturing is dependant on many sub-systems which result in the characteristics mentioned. Toyota has tried to explain the sub-systems by developing the TPS House.

2.3.2 Systems of Lean Manufacturing

Today, lean manufacturing is most commonly known as TPS. In order to better understand the concept of TPS, Toyota developed the TPS House.

Figure 2-2: TPS House



Source: Gemba Research, Undated:2

In order to implement lean manufacturing, Toyota focuses on three main areas. The first area is to maintain a standard work condition or sequence. The second area is to introduce just-in-time (JIT) systems. The concept of JIT is to supply the required part when needed. Since the part is needed just-in-time, it has to be correct. In order to ensure that the part is of the desired standard, a great deal of focus is placed throughout the assembly operation on ensuring that it is being built correctly i.e. Jidoka. Closely linked to JIT and Jidoka is level production i.e. Heijunka. Heijunka is a method of smoothing the production schedule, thus ensuring that the customer's JIT requirements are met. The third area is to continuously improve (i.e. Kaizen) by eliminating areas of waste (Kitano, 1997:4). Further sub-tools are also used to assist in the implementation i.e. Kanban, pull system, flexible manufacturing and visual management (Kilpatrick, 2003:2).

2.3.2.1 Standardized Work

Standardized work focuses on human motion with the main aim being to organize the production sequence in an efficient manner. In order to ensure that improvements can be made, the sequence of events has to be repetitive i.e. standard.

The objectives of a standard work condition is to:

- Reduce operation time;
- Ensure quality and safety by having a repetitive process; and
- Allowing easier analysis of a process since process steps are repetitive (Denso, 2000:46).

2.3.2.2 JIT

JIT was first adopted and publicized by the Toyota Motor Corporation of Japan. The need for JIT was prompted by Japanese firms who could not afford large amounts of warehouse space to house finished goods. The lack of warehouse space meant that the production of smaller batch sizes would have to be made more economically by having flexible lines. The presence of flexible lines would allow smaller quantities to be made at shorter intervals, thereby, overcoming the space constraint (Bamboo Web Dictionary, undated: page unknown).

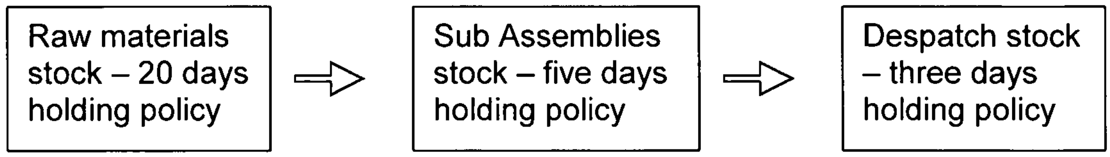
According to Shingo (1989:69), JIT is the procedure where each process is supplied with the required parts in the required quantity and time when needed. The purpose of JIT is to reduce stock holding. Therefore unnecessary funds are not wasted in unutilized goods. The absence of funds being tied up in stock results in a financial gain. In order to benefit from this financial gain, the philosophy of JIT needs to be understood.

Most companies have, in the past, refrained from working on a JIT principle due to:

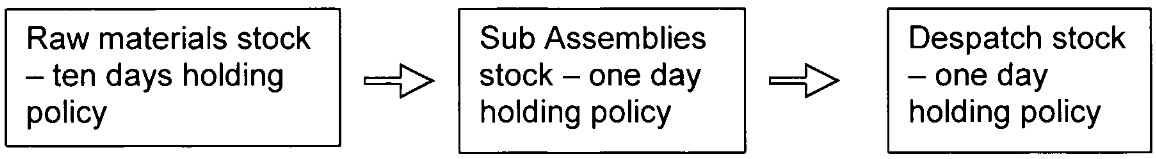
- Batch building to safe-guard production stoppage against late parts delivery;
- Amortize the costs of long machine setups; and
- Safety stock, if there are quality problems with existing stock.

This need to build in batches results in a need for high stock-holding, resulting in funds being used in un-saleable parts. The presence of excess inventory does nothing to reduce costs and masks actual problems due to the presence of buffer stock. The cost associated with buffer stock is evident when one looks at it diagrammatically as shown in **Figure 2-3**.

Figure 2-3: Stock-holding without JIT



Stock-holding with JIT



Source: Self-Generated, 2006

Stock-holding, without JIT, results in stock being in the system for 28 days prior to being sold to the customer. Since the stock has been paid for, the owner loses interest on the funds used to purchase the stock since money is only received when the stock is converted into a saleable item. Stock-holding with JIT results in stock being in the system for 12 days prior to sale, thus saving 16 days of funds being tied up.

JIT focuses on reducing large economic order quantities, reducing set-up times, attacking quality problems, reducing the number of suppliers, inventory reduction in the stockroom and factory floor and involving and respecting every employee (Goddard, 1986:11).

Quality levels are important as JIT works on a principle of zero defects. If quality is below standard, the reduction of stock will immediately highlight problems requiring immediate attention. Reduced stock levels also ensure that the rejects are not warehoused for months prior to being found out that they are rejects (George and Jones, 2006:277). The presence of JIT production and reduced stock levels is different to batch building as the issue can be resolved at a later stage due to the presence of safety stock.

In order for JIT to be introduced, attention must be given to the people, plant and systems. Commitment is needed from all employees. The plant needs to ensure that quality levels are high. Therefore, the introduction of the JIT system needs to be present in order to plan, order and execute. Common criticisms of the JIT system are that:

- JIT increases physical distribution costs;
- It results in a shortage of drivers due to the frequent deliveries;
- Increased traffic congestion; and
- Increased emission of exhaust gases that pollute the environment (Monden, 1994:349).

Monden (1994:349) argues that JIT creates jobs due to increased delivery cycles, reduces traffic congestion as goods are transported throughout the day as opposed to peak traffic times and exhaust emissions are the same if five deliveries are made at once or if they are spread throughout the day.

2.3.2.3 JIDOKA

Jidoka refers to the automatic rejection of a faulty component or the manual ability to stop a process (Toyota Production Systems, 1995:17). The manual ability to stop a process allows the operator to feel that he or she is part of the line management team. Further to the manual ability to stop a process, it is believed that it is better to stop the line and solve the problem permanently than to continue running with the problem persisting (Lu, 1990:72).

Jidoka is a quality system that aids in running a JIT system, which is necessary for lean manufacturing. JIT requires that all parts are supplied correctly a 100 percent of the time thus eliminating line stoppages. A 100 percent quality is maintained by focusing on the part as opposed to the process. Allowing supervisors to take immediate action to correct a problem increases focus on the part. Immediate action is made possible by immediately notifying the problem to a supervisor (Lu, 1990:72).

Notification can occur via visual aids i.e. an ANDON board. An ANDON board informs everyone, including the supervisor, that there is a fault in the system. Once the fault is found, the root cause of the problem needs to be identified. Solving the root cause of the problem will reduce the possibility of this problem occurring in the future. The root cause can be identified via a method called the Five Whys (Toyota Production Systems, 1995:19). The aim of the Five Whys is to continue asking why until the real cause of the problem can be identified.

2.3.2.4 HEIJUNKA

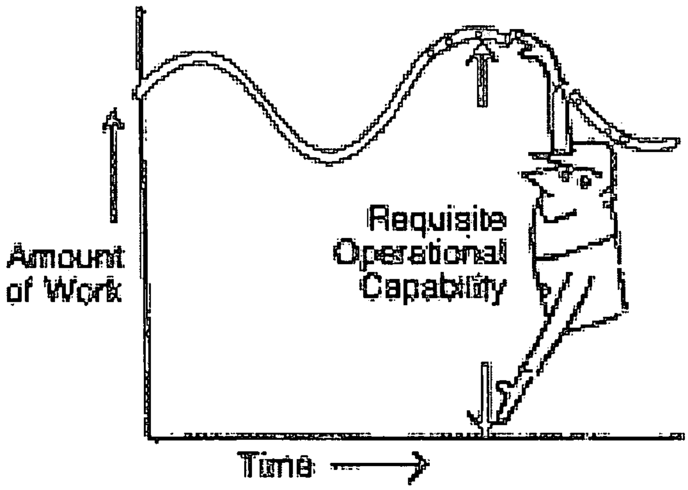
Heijunka is referred to as the load smoothing of production (Lu, 1989:50). Load smoothing is critical to the elimination of waste. Waste occurs in the form of idle time with regards to manpower, equipment and work-in-process (Monden, 1994:8).

In order to understand the benefits of load smoothing and its elimination of waste, the concept first needs to be understood.

Heijunka, in conjunction with Kanban and JIT, can only exist in a system in which the customer draws a set amount of a product at a set time. The absence of this production rule will mean that the supplier will have to keep an excess amount of buffer stock, equipment and manpower to cater for the customer's random pull. The elimination of random pull will allow the supplier to better plan the line by eliminating the quantity variance. Production smoothing, or Heijunka, eliminates the manufacturing quantity variance.

Production smoothing has two phases i.e. the total production-smoothing phase and the model specific smoothing phase (Monden, 1989:63). The total production-smoothing phase is meant to level the daily production after taking the peaks and valleys into consideration. Refer to **Figure 2-4** in the text.

Figure 2-4: Peaks and Valleys of Work



Source: Lu, 1989:45

The production of parts in a process that correspond to the peaks and valleys of the customer's requirement results in waste in two ways. The first form of waste occurs in plants that are set up to run at its peak resulting in poor labour and machine utilization during low production runs i.e. the valleys. The second form of waste occurs if there is no link between the number of units produced by the supplier and the number of units being able to be built by the customer. This deficiency results in process waste, as the customer is unable to consume all the supply (Monden, 1994:64).

In order for the peaks and valleys to be eliminated, the manufacturer needs to know the weekly or monthly requirements. Knowledge of the weekly and monthly requirements will allow the manufacturer to smooth production.

Table 2-1: Smoothing Production

	WEEK				
PRODUCT	**1**	**2**	**3**	**4**	**MONTHLY TOTAL**
Widget 1	100	150	50	100	400
Widget 2	20	0	60	100	180
WEEKLY TOTAL	120	150	110	200	580

Source: Self-Generated, 2006

(N.B.: It is assumed that each widget has the same manufacturing time.)

If a manufacturer needs to produce 580 widgets in a month, he/she will smooth production over the 20 working days in a month. 20 days are attained by assuming that each month has four weeks with five working days per week. The required volume per day is attained by:

Volume per day = (Volume per month)/ working days per month

= 580/20

= 29 units per day

The supplier, therefore, needs to manufacture 29 units per day to ensure smooth production. In order to figure out the model specific smoothing phase, a similar approach is used.

Calculation based on Widget 2 as shown in **Table 2-1**:

Volume per day = (Volume per month)/ working days per month

= 180/20

= 9 units per day

The supplier will have excess stock in weeks one, two and three but this stock will be used to satisfy the requirements of week four. The necessary stock must be present prior to smoothing so that fluctuations in demand can be met. This is evident if 100 widgets were needed in week two but only 45 are manufactured per week. An alternate to keeping stock will be to increase headcount in order to improve output. This increased headcount can then be utilized in other processes or programmes in the plant during periods of lower volume.

2.3.2.5 KAIZEN

Kaizen refers to a new way of thinking that involves the entire process. The Kaizen idea is to continuously improve the process by trying to make it better (NAAMSA, undated: 2). According to Monden (1994:199), Kaizen is also referred to as 5S. 5S Refers to the five Japanese words viz. Seiri (to separate the necessary items from the unnecessary while eliminating the unnecessary items), Seiton (to neatly arrange and identify all items), Seison (to maintain a clean working area), Seikeketsu (to constantly maintain the three S's mentioned thus far) and Shitsuke (to have workers always conform to the rules) which collectively translate to cleanup the work-place. Toyota has assigned English words to each 'S' viz.:

- (S)ifting – this is to only keep required items at the work place;
- (S)orting – items in the workplace should have a specified location i.e. storage area;
- (S)weeping – areas should be clean and tidy which promotes a safe working environment;

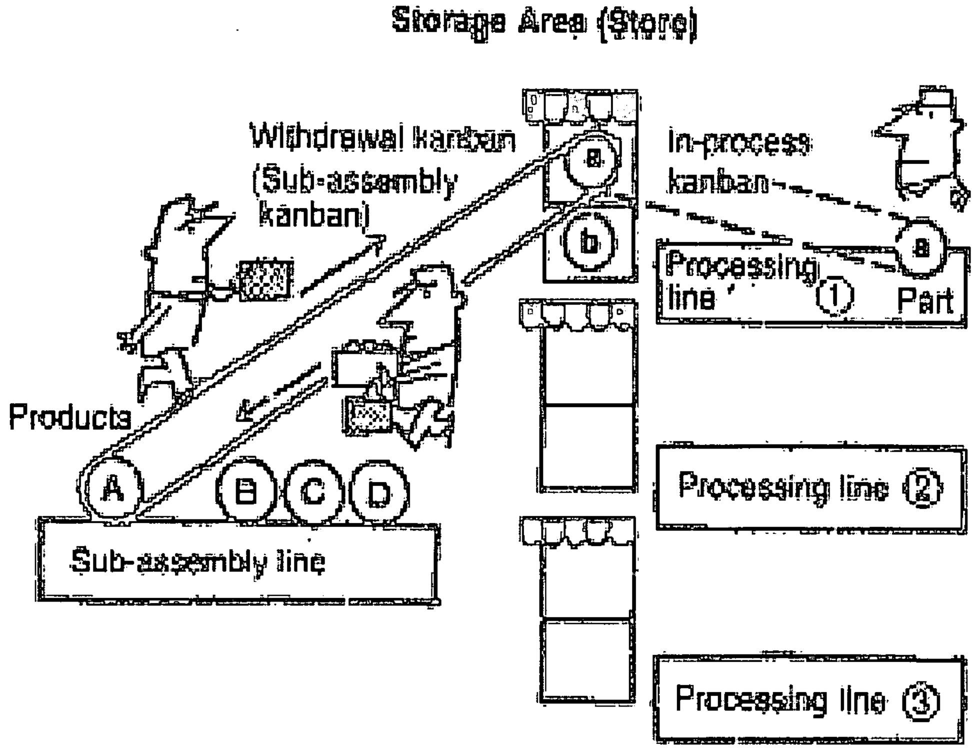
- (S)pick and Span – this refers to the overall cleanliness of the area which is dependent on the other S's; and
- (S)afety – it is the responsibility of everyone since if affects the worker directly (An Introduction to Toyota Production Systems: The Cornerstone of Toyota's Competitive Success, Undated:8).

The elimination of all unnecessary items and a clean work environment will improve quality levels, decrease manufacturing lead-time and result in cost reductions (Monden, 1994:199).

2.3.2.6 KANBAN

In order for the JIT system to work, suppliers need to send small amounts of stock to the customer. This stock arrives at the customer in small wheeled containers known as Kanban. According to Goddard (1986:11), Kanban is the Japanese word for sign or visible record.

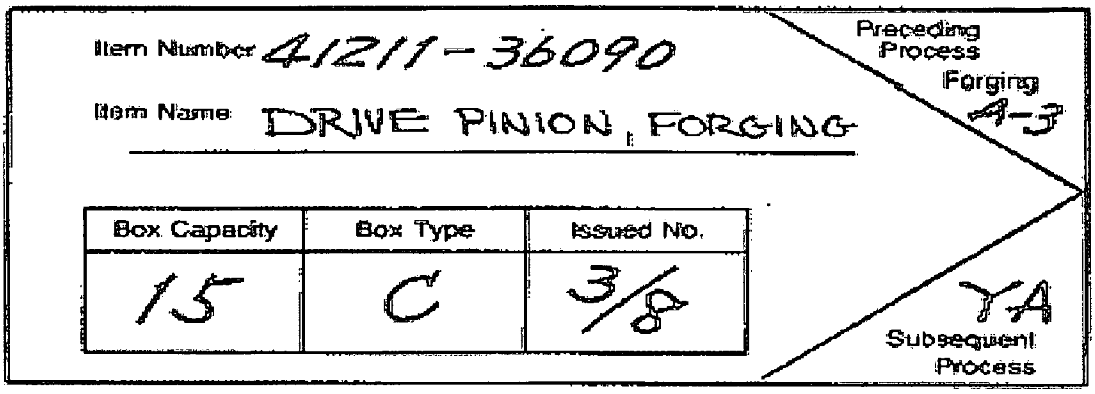
Figure 2-5: Operation Procedure of Kanban



Source: Lu, 1985:93

The visible record is evident when an understanding of **Figure 2-5** is present. The sub-assembly line in **Figure 2-5** manufactures part "A". The sub-components of part "A" are stored in the store. This store is fed by processing line "1" which manufactures sub-component "a". When "A" requires part "a" from the store, it provides the store with a sub-assembly Kanban card and takes a set quantity. The details on the sub-assembly card are:

Figure 2-6: Details on Kanban Card



Source: Lu, 1985:84

This sub-assembly Kanban card then prompts processing line one to manufacture sub-component "a". As can be seen, the card informs the manufacturer of the desired quantity to produce (i.e. 15) and the part to produce (i.e. a drive pinion). The manufacture of the component restores the stock in stores to its required level.

In store, stock is of a set quantity thereby maintaining the principle of JIT and lean manufacturing. In order to understand the JIT purpose of Kanban, the following rules must be applied when running a Kanban system i.e.:

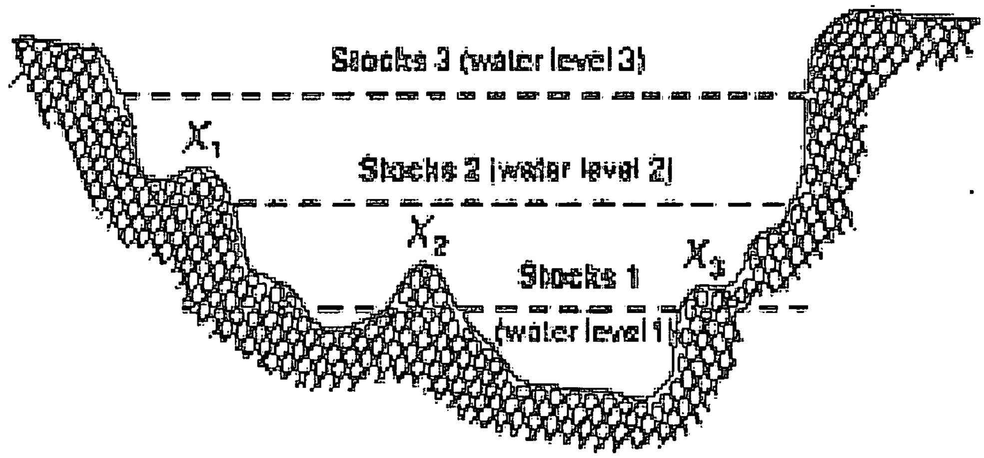
- The customer needs to draw stock from the supplier in set amounts at set times. Any deviation from this time and quantity should be prohibited;
- The supplier needs to produce its products in the quantities used by the customer. This synchronized quantity aids in creating a conveyor system between supplier and customer thereby aiding balanced production. This balanced production further contributes to minimized

stock-holding which is a requirement of lean manufacturing;

- Defective products should never be present in the Kanban area as this would result in product shortages. Since stock holding is minimum, this absence of parts will be highly visible;
- The number of Kanbans should be minimized as excess stock creates a buffer for inefficient processes. Reduced stock highlights these inefficiencies which prompts immediate response and continuous improvement i.e. Kaizen; and
- The Kanban should be used to adapt to small changes in demand. Changes in excess of 20 percent cannot be controlled using a Kanban system (Factory Logic –Software and lean Initiatives, 2004:4). Quick response to changes in demand are not present in a non-Kanban system as each line reacts to a production schedule. The immediate production of parts, as per schedule, may not be possible due to excessive changeover times and the absence of level production or Heijunka. Production of parts, as per schedule, is different with a Kanban system, as only the final assembly line needs a schedule while Kanban cards prompt all sub-assembly lines. The Kanban card eliminates the need for all lines to have a schedule and improves reaction time. Reaction time is also improved due to the presence of a JIT system (Monden, 1994:24).

According to Shingo (1989:188), Kanban is a good improvement tool. The aim of the improvement is to reduce stock-holding, which reduces funds tied up in unused stock. As the stock levels decrease, the company proceeds to leaner manufacturing. This reduced stock-holding forces the manufacturer to continuously improve the process to quickly react to any change in demand. This improvement is evident when one looks at the pond metaphor as shown in **Figure 2-7**.

Figure 2-7: Improvement Function of Kanban



Source: Shingo, 1989:188

As stock levels decrease, the problems depicted by "X1" to "X3" are highlighted. These problems, once addressed, will result in leaner manufacturing. In order for leaner manufacturing to exist, Kanban needs to function in conjunction with other lean systems such as Heijunka which was discussed in 2.3.2.4.

2.3.2.7 PULL SYSTEM

This is the production and movement of parts when needed in the required quantities. Since the parts are supplied in the required quantities and time, the pull system follows the principles of JIT. Like JIT, the pull system is driven by the customer (Toyota Production Systems, 1995:8).

Opposite to the pull system is the push system. The push system was the operating system, of the past where parts were supplied or pushed to the customer prior to being needed. The pushing of stock resulted in the customer holding a greater amount of stock than required. The presence of unused stock resulted in unnecessary funds being utilized to manufacture parts that were not yet needed (Toyota Production Systems, 1995:8).

2.3.2.8 FLEXIBLE MANUFACTURING

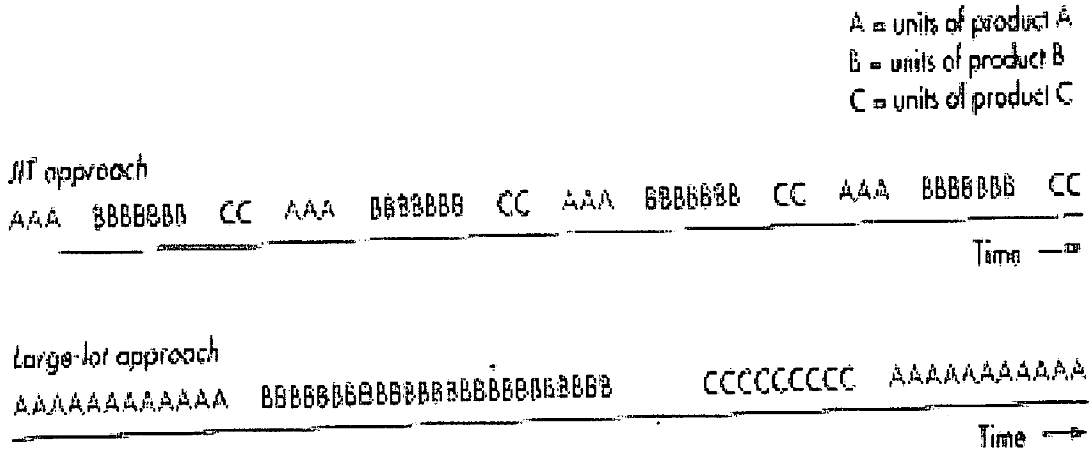
In order for a manufacturing line to make money, it needs to ensure that it experiences as little downtime as possible. Downtime occurs due to many reasons such as breakdowns and changeovers or machine setups.

Total Productive Maintenance (TPM) (Zimmer, 2000:3) reduces breakdowns in a lean environment. TPM reduces breakdowns by utilizing the machine operators for minor maintenance such as cleaning, lubricating and minor adjustments while using a small group of individuals to improve reliability. Setups or changeovers result in lost funds as operators and machines are inoperative. Operators' and machines' inoperative time can vary from a few seconds to a few hours. It is because of the duration of a changeover that flexible manufacturing has been introduced.

According to Nemetz and Fry, as cited by George and Jones (2006:282), flexible manufacturing aims to reduce set up time by redesigning the manufacturing process. Redesigning the process aids in reducing time lost thereby aiding the company to produce a greater variety of parts in a shorter time frame as shown in **Figure 2-8**. Methods of redesigning include:

- The use of multipurpose equipment or attachments which can be rotated to reduce changeover time;
- The use of similar parts between variants to reduce the extent of the changeover; and
- The scheduling of production such that similar products are run sequentially to reduce setups even further (Stevenson, 1999:665).

Figure 2-8: Benefit of Flexible Manufacturing



Source: Stevenson, 1999:666

Flexible manufacturing complements the requirements of JIT, Kanban and lean manufacturing as Kanban stock can be replenished at a quicker rate due to a little of everything being produced during the cycle, as shown in **Figure 2-8**.

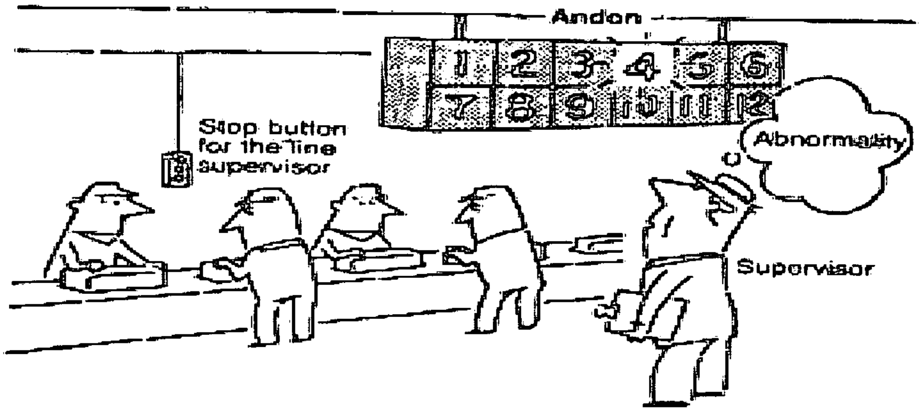
2.3.2.9 VISUAL CONTROLS

Visual controls are simple signals that provide an immediate understanding of the line condition or situation. Line condition will include status of production schedule, backlog, workflow, inventory levels, resource utilization and quality (Kilpatrick, 2003:3).

Line condition can be conveyed to the necessary personnel via an Andon system. Andon refers to a Japanese paper covered lamp (Lu, 1985:27). This lamp system has been used to convey the condition of a production line. According to Shingo (1989:74), an Andon system is a visual control that communicates important information via a visual signal i.e. a light. An Andon board usually has five colours with each colour having a specific meaning. The colours used are:

- Red – this indicates a problem with machinery;
- White – this indicates that the required production has been produced;
- Green – production cannot occur due to the shortage of materials;
- Blue – a unit is defective; and
- Yellow – the line is currently undergoing a changeover (Monden, 1994:232).

Figure 2-9: Andon Lights



Source: Lu, 1989:74

This information will act as a signal for supervisors who will need to take action according to the signal to eliminate the problem by returning the line to its required operating state. The supervisor will also know at which station the problem occurs, as can be seen in **Figure 2-9**. Andon can also be used to indicate the efficiency of the line by having digital display panels, which show the pace of production. Digital display panels allow both the supervisor and the operator to monitor the performance of the line.

2.3.3 BENEFITS OF LEAN MANUFACTURING

The implementation of lean manufacturing offers benefits to the company, the employees and the customer.

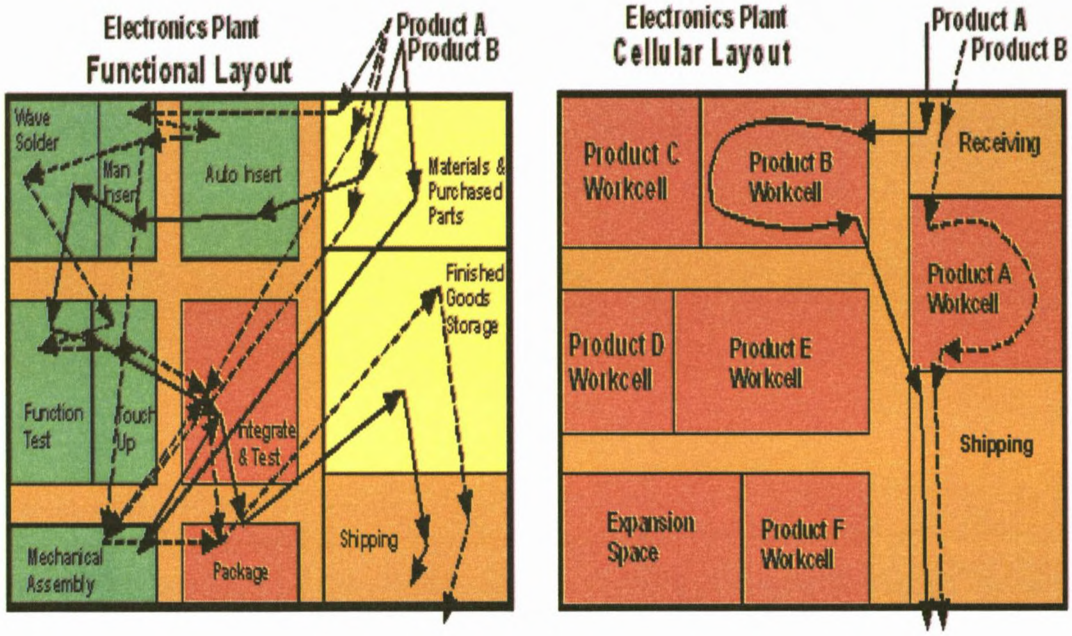
An improvement in the company's operating procedure benefits both the company and the employees. Lean manufacturing reduces waste in the company by improving the company's bottom line. Improvements in the bottom line enable the company to become more competitive as these savings can be transferred to the customer, thereby ensuring the continued existence of the company. The continued existence of the company ensures the required need for labour (Strategos Consultants, Engineers and Partners, Undated:1).

Labour utilization is improved by the introduction of lean manufacturing by moving away from using one worker per machine to one worker to several machines. According to Continental Design Engineering (2008:1), production by labour in Prime Products had increased by 50 percent after the implementation of lean manufacturing. Using one worker to several machines is made possible through standardized work and continuous improvement. Continuous improvement helps the worker work more efficiently by allowing him or her to perform multiple tasks. Continuous improvement in working conditions improves processes as error-proofing and other scrap reduction is incorporated into optimising the process (Zimmer, 2000:4). Process optimisation incorporates improvements in quality and efficiency. Improved quality always benefits the customer as the reliability of the product is improved. Improved reliability of the product and delivery will aid the customer in reducing stock holding, thereby saving him/her money.

Efficiency is improved by reducing waste that normally occurs as a result of volume production, inefficient setup procedures, poor machine operation and layout, lack of performance standards, poor shop floor co-ordination and control (Nicholas, 1998:144). Improvements in these areas result in improved material handling, scheduling, quality and employee benefits.

The benefits of lean manufacturing on material handling are evident when one compares the improvements attained by changing a functional layout into a cellular layout, as shown in **Figure 2-10**.

Figure 2-10: Functional vs Cellular Layout



Source: Benefits from Lean and Cellular Manufacturing, Undated: 3

Figure 2-10 depicts the benefits of a cellular layout, viz.:

- Reduced queues and improved material handling; and
- Reduced travelling distances with routes being simplified, thus allowing cheaper and smaller handling devices, such as conveyors, to be used (Benefits from Lean and Cellular Manufacturing, Undated:1).

Cellular layouts improve information flow between workers as work cells are self-contained. The transfer of information becomes quick, simple and informal, which strengthens the relationship of the team members. Improved relationships between team members strengthen the team. The motivation of the team then changes from extrinsic needs to intrinsic needs. This intrinsic need is crucial to the functioning of the cell where the function of the worker is not limited to his/her job skill. The intrinsic need prompts cellular workers to take greater responsibility for their work (Benefits from Lean and Cellular Manufacturing, Undated: 1).

Research conducted by Zimmer (2000:1) revealed that companies implementing lean manufacturing have achieved improvements in excess of ten percent increase in direct labour utilization, 50 percent increase in indirect labour use, 50 percent reduction in inventory, 70 percent decrease in manufacturing cycle time and 50 percent increase in capacity on current machines.

The NIST Manufacturing Extension Partnership, who surveyed 40 of their clients that implemented lean manufacturing, conducted similar research. Their results revealed that lean manufacturing resulted in improvements in 90 percent reduction in lead time, 50 percent increase in productivity, 80 percent reduction in work-in-process, 80 percent quality improvement and 75 percent reduction in space utilization (Kilpatrick, 2003:3). These savings result in a financial gain to the company by reducing the manufacturing cost of the component. The reduction in manufacturing cost may assist in improving the competitiveness of the product and the company.

Continental Design Engineering further supports the benefit of Zimmer and the NIST Manufacturing Extension Partnership. Continental Design Engineering (2003:2) have introduced lean manufacturing in Lincoln Nebraska, Rotor Re-Manufacturer Oklahoma and Electrical Connector Mexico. These companies have had productivity improvements of 44 percent, 36 percent and 76 percent, respectively. Improvements in lead time increased by 98 percent for Lincoln, 47 percent for Rotor Re-Manufacturer and 96 percent for Electrical Connector.

2.3.4 LIMITATIONS OF LEAN MANUFACTURING

The benefits of lean manufacturing can only be realized once the barriers to successful implementation have been removed. Some of these barriers occur as a result of:

- The failure to convert the improvement to a monetary value which links to the financial statements;
- Incorrect implementation procedure;
- The implementation on a difficult or low priority line, which shows the complexity or is unable to show the actual benefits of lean manufacturing;
- Failure to introduce lean implementation to the supply chain;
- Failure to pursue lean principles after the introduction;
- Failure of the company to adapt to change; and
- Incorrect balance between training and implementing (Kilpatrick, 2003:4).

Other barriers to implementing lean manufacturing, as stated by McGivern and Stiber (Undated: 5), include:

- The lack of understanding the reason to change;
- The use of lean manufacturing to promote downsizing of the work force;
- Opposition from middle management;
- Poorly defined measuring systems which are unable to convey the benefits of lean manufacturing;
- Short-term versus long-term thinking;
- Inadequate union involvement; and
- The lack of commitment and ability to implement the system.

The disadvantages to lean manufacturing are that while the cost of buffer stock is high, the absence of it can affect a customer during problems down the supplier chain. The presence of buffer stock can also increase a supplier's responsiveness to an increase in customer demand (George and Jones, 2006:283).

2.3.5 LEAN IMPLEMENTATION

While academics have different procedures to implementing lean manufacturing, the gist of the implementation remains the same: i.e. continuous focus and awareness with the necessary change in organizational culture is necessary for the implementation procedure. Three implementation procedures will be discussed. Procedure one offers a 13 point introduction, procedure two offers a five year introduction plan and procedure three offers a one year introduction plan.

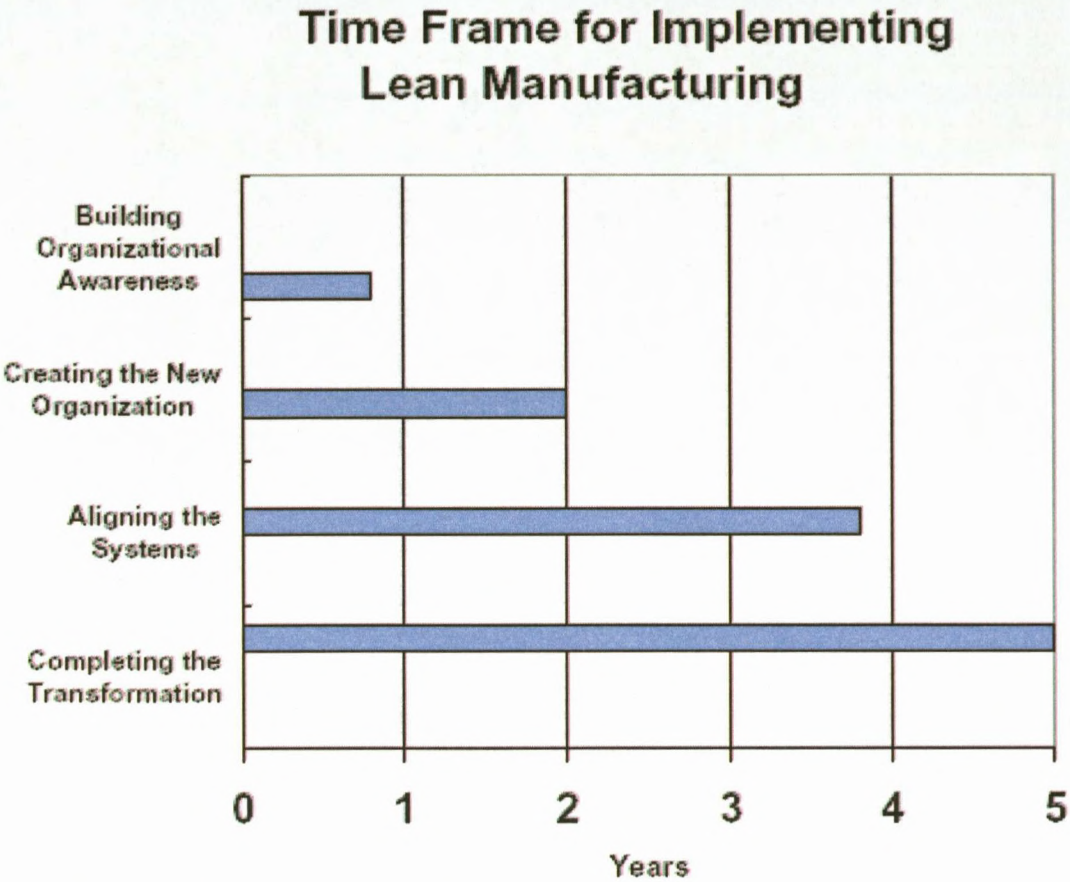
According to procedure one, a company needs to undergo 13 steps to become a lean enterprise (Liker, 2004:302). These 13 steps include:

- Begin with changes/improvements in the technical systems followed by cultural change. Leaders must be actively involved in the system implementation as this will assist cultural change;
- Learn by doing first and training second. The idea of doing first is to allow people to identify problems and develop solutions. The process of identifying problems and developing solutions facilitates the learning process. According to Liker (2004:302), the ratio of doing to learning is 80 percent doing to 20 percent learning;
- Implement lean on one line first so that employees can see the benefits of the system;
- Plot material and information flow diagrams of actual occurrences. Plotting the path of a part from start to finish helps the team collectively see and identify areas of waste;
- Continuous improvement workshops should be held to teach employees to identify areas of improvement. Once these areas have been identified, the implementation of these improvements must be accelerated;
- Have one manager that is responsible for the entire lean implementation process. The management structure during this implementation procedure will be that of a matrix organization;

- Ensure that lean is mandatory and consequences exist for not adhering to the implementation time table;
- Leadership must be focused on long-term improvement;
- Choose lines that will be able to show the financial benefits of lean manufacturing. This financial benefit will be used to sell the system and attain buy-in from other members in the organization;
- Measure those aspects that add value to becoming a lean organization i.e. adherence to daily scores cannot exist in a lean organization as production needs to stop if the customer has not requested stock;
- Modify the lean manufacturing system to meet the needs of the company. Modification of the lean manufacturing system is evident with Toyota who has called lean manufacturing the Toyota Production System;
- Top management need to understand the system so that it can be driven top-down; and
- If management don't have a sound understanding, a lean manufacturing expert must be hired.

Procedure two, while similar to procedure one, varies as it provides a time frame for implementation. According to McGivern and Stiber (Undated:2), lean manufacturing implementation takes five years with each step shown in **Figure 2-11.**

Figure 2-11: Time Frame for Implementing Lean Manufacturing



Source: McGivern and Stiber, Undated:3

The implementation procedure, being time-based, is as follows:

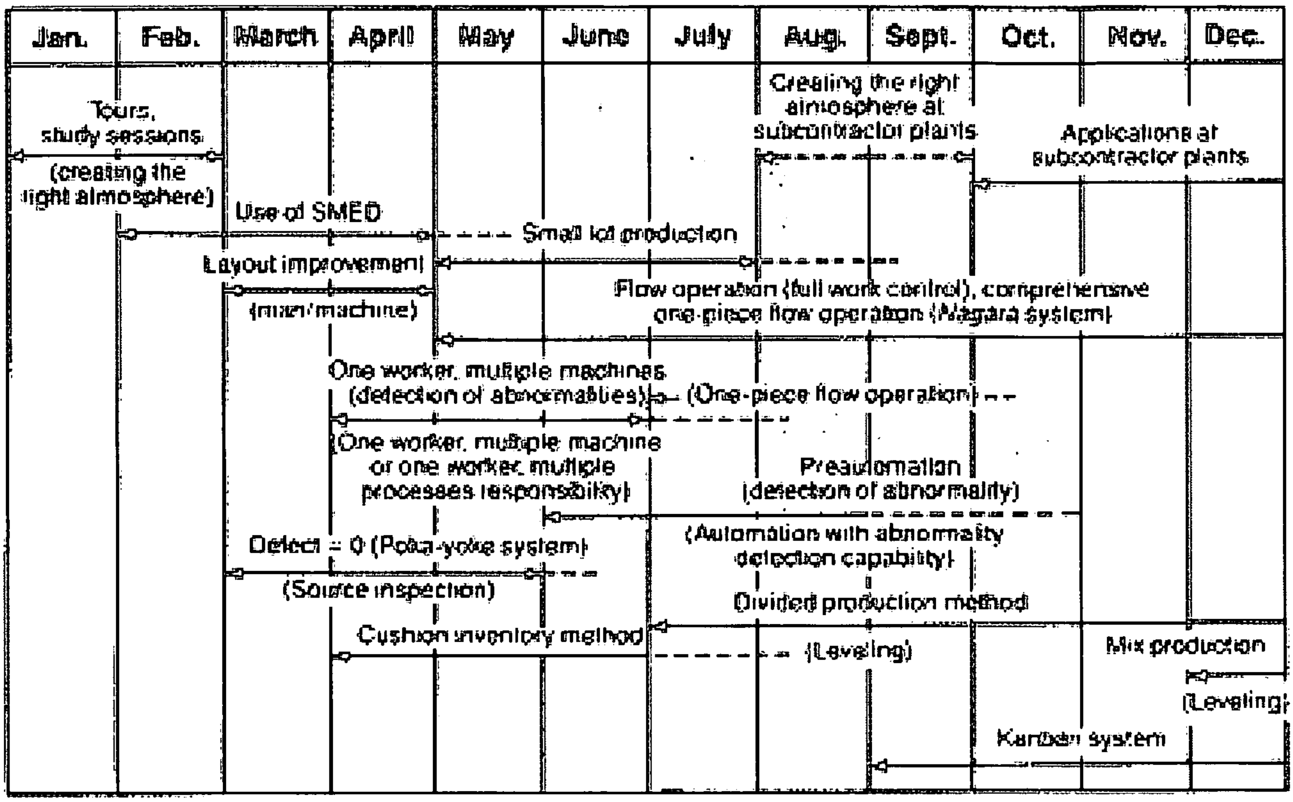
- Month one to six – organizational awareness regarding the need and benefits of lean manufacturing is increased. The role of lean manufacturing in assisting the company attain its vision is also communicated. The lean manufacturing implementation procedure has a well defined timetable, thus enabling the implementation to be monitored;
- Month six to year two – the new organization is created using the principles and techniques of lean manufacturing. Principles and

techniques of lean manufacturing apply both to the people and the processes in the organization;

- Year three to four – improvements are being noted in the organization with Kaizen being driven from bottom-up as opposed to top-down. The improvements of lean manufacturing are being monitored which will assist in maintaining this new culture; and
- Year five – the lean manufacturing implementation and transition of the new organization is complete. Lean manufacturing is then introduced to suppliers with Kaizen being a way of life for the organization and its suppliers.

Shingeo Shingo (1990:224), while offering a similar introduction system to the above two, uses different terminology to express his implementation procedure as evident in **Figure 2-12**.

Figure 2-12: Plan for Introducing Lean Manufacturing



Source: Shingo, 1990:223

Shingo, however, believes that the time frame will vary depending on the capacity of the manufacturing plant. He also believes that the introduction of the system can occur at any point depending on the improvements already present in the plant.

All three experts believe that the level of commitment from all involved will determine the success or failure of lean manufacturing. The order of the introduction of certain lean sub-systems may vary but the organization must be willing to accept the change for the benefits of lean manufacturing to be realised.

Accepting change is easier said than done as it involves changing one's culture. According to Edgar Schein as cited by Kreitner, Kinicki and Buelens (1999:89), culture is defined as a pattern of basic assumptions that has worked well enough in everyday life which has thus impacted on how a person behaves and thinks. This social culture, when brought to work, affects employees which shape the organizational culture. Change in the organizational culture is prompted by external forces, which impact internal forces in the organization. External forces include demographic characteristics, technological advancements, market changes and social and political pressures (Kreitner, Kinicki and Buelens, 1999:585). In order to implement change in an organization, a possible change tool will be Kotter's Eight Steps for Leading Organizational Change. According to Feld (2001:24), organizational change can also be aided if management address the following:

- Communication Planning: all members of the organization need to be informed in advance of the need for changing the manufacturing process. The purpose of advanced notification is to reduce the fear that may arise from change. The content of notification needs to vary depending on the target audience. Target audience includes executive management who need to understand and approve the process, middle management who need training and education and base level employees who need to be assured that they are part of the project;
- Product Focused Responsibility: the organization needs to assign a person who will be responsible for the implementation of lean manufacturing in a specific cell. The presence of an individual will

ensure that all questions can be focused on him or her to eliminate the problem arising of not having a person accountable;

- Leadership Development: in order for an organization to progress and adopt world class manufacturing principles, it has to have employees with the necessary skills. Competent employees are necessary as they will be responsible for planning, leadership, problem solving, team building technical assistance and interpersonal communication. In order to identify these qualities in present employees, a formal selection procedure needs to be followed to eliminate subjectivity;
- Operational Roles and Responsibilities: organizations need to ensure that work cells have the minimum number of people present in the cell. Presence of minimum people will aid in motivating people to improve due to limited labour. It will also eliminate the need of people being transferred due to high labour content per cell; and
- Workforce Perception: the limited number of heads per cell will also encourage flexibility, as people will have to be multi-skilled for the cell to be efficient. Multi-skilled people will be involved in job rotation, which stimulates interest and provides motivation while providing employees with a broader perspective of the organization (Kreitner, Kinicki and Buelens, 1999:191).

Willingness by all in the organization for change, coupled with the lack of a controlled change programme, will affect the implementation of lean manufacturing, irrespective of the lean manufacturing procedure used.

Organizations thus need to focus on preparing the organization for the change process prior to implementing lean manufacturing.

2.4 LEAN MANUFACTURING IN THE MOTOR INDUSTRY

2.4.1 CHANGES IN THE MOTOR INDUSTRY MANUFACTURING PROCESSES

The top three vehicle manufacturers in the global motor industry are General Motors, Ford and Toyota. In 2004, Toyota was the third largest manufacturer of vehicles but its annual profit for 2003 was larger than the combined earnings of General Motors, Ford and Chrysler. Toyota's net profit margin was 8.3 times higher than the industry average with Toyota selling more vehicles in North America in 2003 as compared to the top three American motor vehicle manufacturers (Liker, 2004:4).

The main contributor to Toyota's success is the introduction of lean manufacturing in Toyota and throughout its supply chain. Lean manufacturing and the Toyota Way of Life have helped Toyota grow without merging with other motor vehicle manufacturers.

In 1999, mergers, acquisitions and alliances in the automotive industry have contributed to the value of $71.3 million dollars. Daimler Chrysler and SAMCOR have grown by Daimler Chrysler being a mixture of Mercedes Benz and Chrysler while SAMCOR is made up of Ford and Mazda (Primedia, 2006:2). Motor vehicle suppliers also reduced from 30 000 in 1988 to 8 000 in

1999 (Pitot, 2000:3). Failure to merge or become more competitive will lead to closure in a constantly improving industry.

Vehicle manufacturers have realised that improving their manufacturing processes will aid in attaining a competitive advantage. They are, however, not as experienced as Toyota, who has been working with lean systems since the 1940's (Liker, 2004:8). Similarities are evident between systems used by other manufacturers such as Ford and General Motors and the Toyota Production System or Lean Manufacturing.

Ford has changed from a manufacturer of batch production to a lean manufacturer. Ford has adopted the principles of lean manufacturing and has developed its own "Ford Production System". Improvements in Ford have been vast and resulted in their Ohio plant being awarded the 2001 Shingo prize for reaching a lean manufacturing milestone (Ford Ohio Assembly Plant Wins Shingo Prize for Lean Manufacturing, 2001:1).

General Motors have adopted a flexible manufacturing system, C-Flex, in order to improve their manufacturing process. C Flex is a multi-product tooling system that allows various parts to be manufactured by merely re-programming the tool. The introduction of C Flex has reduced the introduction costs of a new model from $150 million to $30 million (Peter, 2003:1). C Flex has also reduced space utilisation by 150 000 square feet. General Motors's C Flex manufacturing system encompasses the flexible manufacturing philosophy of lean manufacturing.

Smaller vehicle manufacturers will have no choice but to change to lean manufacturing if they wish to remain in business and compete in the global arena. The success of Toyota and other companies that have adopted lean manufacturing will aid them in changing towards a lean manufacturing system. Toyota's success with lean manufacturing, together with their zeal to improve suppliers along the supply chain, has resulted in Smiths Manufacturing implementing lean manufacturing. Coupled with Toyota's drive of supplier development, is the need for Smiths Manufacturing to improve global competitiveness and decrease costs. According to Pisano and Hayes (1995:xiii), manufacturing companies need to implement these systems in order to be able to compete.

2.4.2 SMITHS MANUFACTURING

2.4.2.1 OVERVIEW OF SMITHS MANUFACTURING

Smiths Manufacturing is a major supplier to Original Equipment Manufacturers (OEM's) and supplies products both locally and internationally to the following customers shown in **Figure 2-13**.

Figure 2-13: Customers of Smiths Manufacturing

TOYOTA	DAIMLERCHRYSLER	GM
	FIAT	NISSAN
Ford	★ Visteon	
★ Bergstrom (Lotus)	★ LAND-ROVER	★ AVA Italia AVA Benelux BV

★ Export Customers

Source: Associate Handbook, 2006:9

Smiths comprise of three consolidated companies i.e. Smiths Manufacturing, Smiths Plastics and Smiths Electric Motors. All three companies together have a cumulative employee base of 1308.

Metair Investments Limited owns 75 Percent of Smiths while Denso owns the remaining 25 percent. The company is listed on the Johannesburg Stock Exchange with it being ranked amongst the top 300 companies in South Africa (Smiths Rated Amongst the Top 300 Companies in South Africa, 2005:36).

The core products of Smiths Manufacturing are designed, tested and produced to world class manufacturing standards utilising the expertise and technology obtained under licence to international first tier motor industry component manufacturers and suppliers. The core product range comprises heater cores, radiators, condensers, automotive climate control evaporator and heater assemblies, refrigerant pipes and hoses, electric motors, blower assemblies and plastic injection mouldings.

Increasing competition from both national and international markets has meant that Smiths Manufacturing has had to find new means of being competitive and remaining in business. Smiths Manufacturing has tried to remain in business by selling 25 percent of its shares to Denso. This alliance with Denso has resulted in Smiths attaining new business and valuable technology and information from a first world supplier.

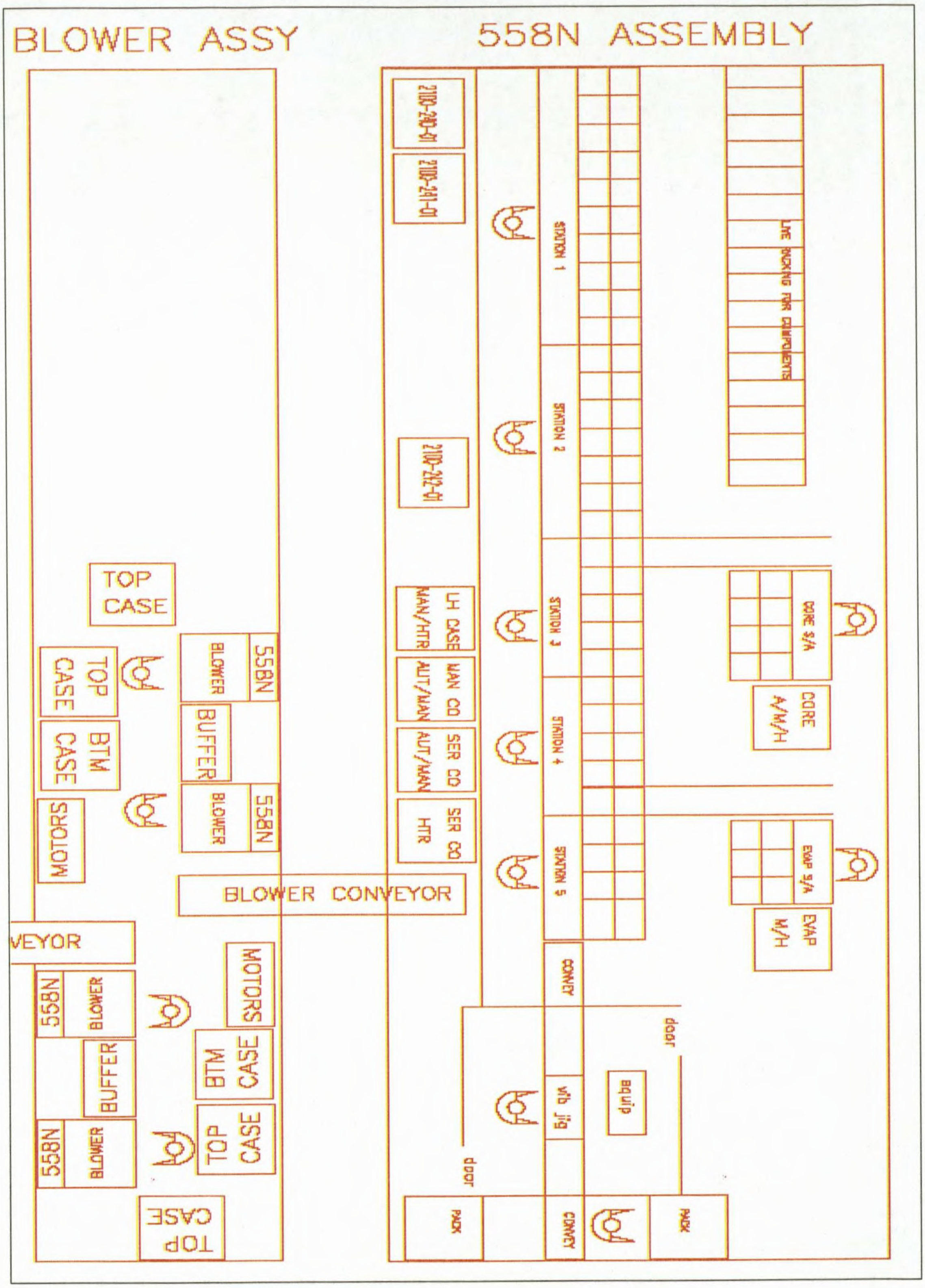
In order to improve competitiveness, Smiths, together with assistance from its major customer, Toyota, has tried to improve its manufacturing processes by introducing lean manufacturing in 2004 on certain lines.

2.4.2.2 CONVERSION OF THE 558N ASSEMBLY LINE

In order to ensure a thorough analysis of the implementation procedure, the pilot line for lean manufacturing changes will be assessed i.e. 558N Assembly Line.

The 558N line is responsible for the assembly of the heating ventilating and air-conditioning unit (HVAC) for the current 2006 Toyota Corolla. The layout of the line from January 2004 was as shown in **Figure 2-14**.

Figure 2-14: 2004 Layout of 558N HVAC line



Source: Pillay, 2004:1

The particulars of the line are as shown in **Table 2-2**.

Table 2-2: Particulars of 558N HVAC line in 2004

ITEM	DETAILS
Number of operators	12
Number of line feeders	1
Supervisor	1
Capacity per day	225
Variants run on line	3 (2100-350-01, 2100-351-01, 2100-352-01)
Customer requirement per day of 2100-350-01	16
Customer requirement per day of 2100-351-01	128
Customer requirement per day of 2100-352-01	20
Change over time	30 Minutes
Change overs per day	3
Efficiency loss due to change over	13%
Raw material stock on line	8 Hours
Plastic casings on line	16 Hours
Finished goods stock in despatch	4 Days

Source: Self-Generated, 2006

A summary of the sequence of events on this line is shown in the process flow diagrams i.e. **Figure 2-15-1 and Figure 2-15-2**.

Figure 2-15-1: Process Flow Diagram for 558N HVAC Line – page one

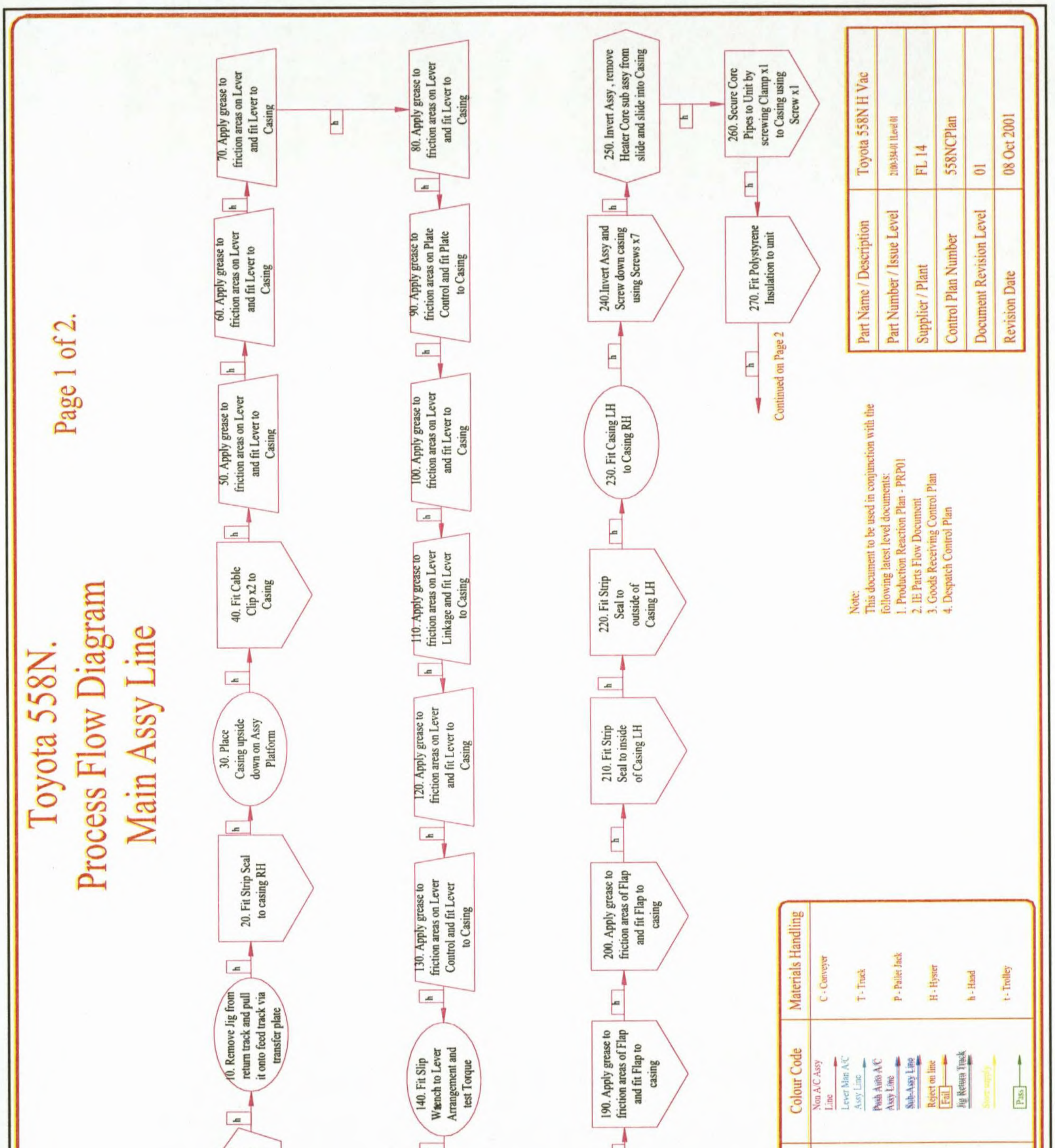
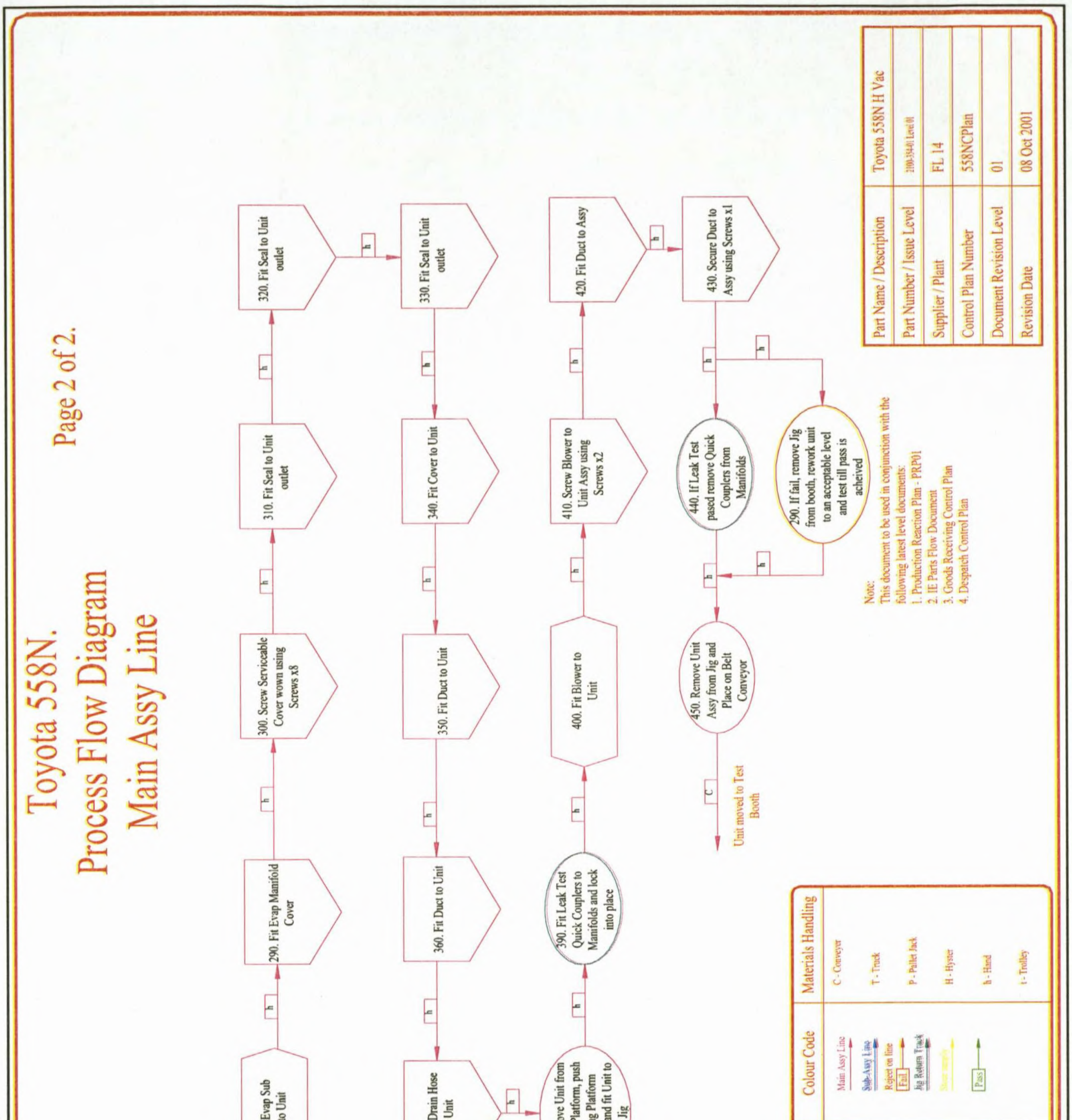


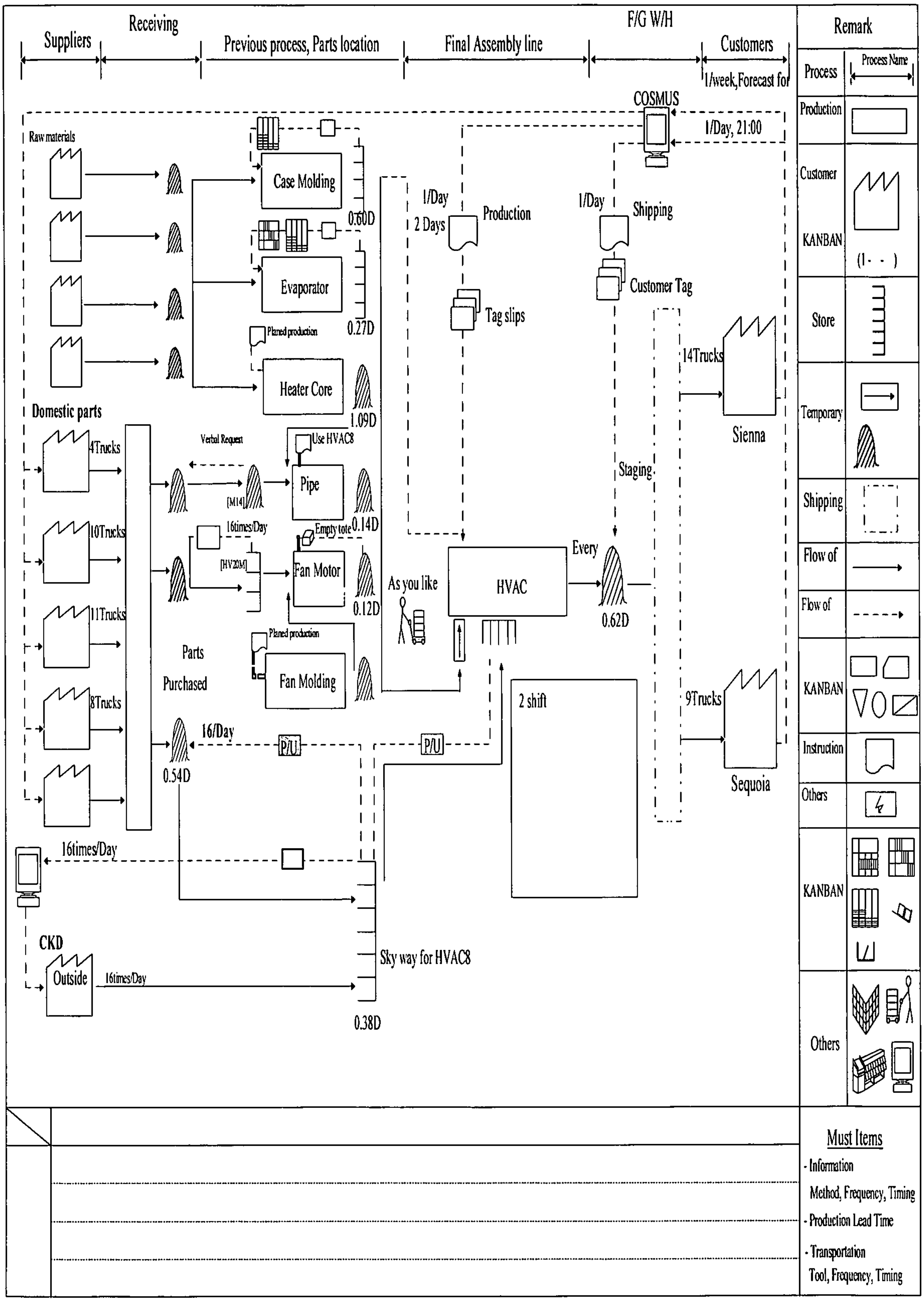
Figure 2-15-2: Process Flow Diagram for 558N HVAC Line – page two



Source: Hamel, 2005:1

The sole purpose of the 558N HVAC line is to assemble parts from both internal and external suppliers to assemble the air conditioner for the 2006 Corolla. The suppliers to the line are shown in the material flow chart of **Figure 2-16**.

Figure 2-16: Material Flow Chart of the 558N HVAC Line



Source: Pillay, 2004:1

An understanding of the line, it suppliers and its customer requirements is vital to the implementation of lean manufacturing as these are the areas that are affected. In the past two years, the line has undergone two major changes, which have impacted on the operating costs of the line. These costs will be analysed in Chapter Four in order to determine the viability of lean manufacturing implementation.

2.5 CONCLUSION

The chapter has outlined the history of lean manufacturing together with the systems that drive the philosophy. An insight was then given into the implementation of lean manufacturing coupled with possible problems during the implementation process.

Once an understanding of lean manufacturing had been attained, the need for the system in the motor industry and in Smiths Manufacturing had been highlighted.

The chapter concluded with the outline of the line being assessed in Smiths Manufacturing. The following chapter identifies the research process in collecting the relevant data.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

Chapter Two reviewed the relevant literature pertaining to the history, definition, sub-systems, benefits, limitations and implementation of lean manufacturing. In Chapter Three, the data used in the research process are identified and the selection criteria are highlighted. Furthermore, an overview is presented on the research methodology used and its application on the sub-problems.

3.2 RESEARCH DESIGN

Three research objectives exist and two methods of research were used to solve the research questions. The first and second research objectives (i.e. to analyze the manner in which lean manufacturing was introduced in Smiths Manufacturing and its benefit on the company's competitive position and future existence) were analyzed qualitatively. The third research objective (i.e. to determine the financial benefit of lean manufacturing introduction on the respective assembly line) was analyzed quantitatively.

Interviews and focus groups were the initial proposed research tools to be used to investigate the manner of lean manufacturing introduction and its benefit on the company's competitive position and future existence. The use of focus groups and interviews changed to the use of interviews only due to the difficulties in attaining all focus group participants at a set location and set time.

Interviews were the first method of choice as the company's internal data archives are not organized and, in certain cases, non-existent. There was an absence of organized data archives as not all the changes involving lean manufacturing on the relevant assembly line have been properly documented. Most of the engineers, managers and operators involved in the implementation were interviewed.

Research investigation for the third research objective (i.e. to analyze the financial benefit of lean manufacturing introduction on the respective assembly line) was done by comparing the conditions before and after lean manufacturing introduction. Some areas of consideration were space utilization, capacity, line headcount, cost of stock, cost of work in progress and cost of lean manufacturing implementation. The effect of lean manufacturing on this line was used to project the impact on the company if it was introduced on all other lines. The financial impact was used to project its effect on the company's competitive position and future existence.

Triangulation is recommended to enhance credibility (Mertens, 1998:297). Credibility was enhanced as using both a qualitative and quantitative approach to make a more accurate deduction about the company problem. The qualitative analysis of the manner of lean manufacturing introduction and its benefit focused on the employees' perspective while the quantitative analysis of the benefit of lean manufacturing focused on the financials i.e. impact of changes. Data was attained and analyzed from the personal interviews with operators. These results were utilized during the interviews with the engineers and managers that were involved in lean manufacturing introduction and implementation. Lastly, the data from all interviews together with the data from the process changes were used to draw conclusions about the manner of lean manufacturing introduction, its benefit on the company's competitive position and its financial implications. The findings were then compared with other companies that have implemented lean manufacturing. The comparison will aid in showing if the implementation of lean manufacturing has had a similar effect in Smiths Manufacturing.

3.3 DATA COLLECTION METHOD

Two types of data collection methods exist i.e. monitoring and interrogation/communication processes (Cooper and Schindler, 1998:131). Both monitoring and interrogation were used.

The interrogation/communication mode were used to assess the manner in which lean manufacturing was introduced in Smiths Manufacturing. This mode was also be used to assess its benefit on the company's competitive position and future existence. Interrogation took the form of interviews. Each interview was semi-structured with questions stemming from the objectives of the study and the literature review. The purpose of the questions was to test the interviewee's knowledge of lean manufacturing and to attain information about the implementation process. The questionnaire consisted of 39 questions, of which 17 test knowledge and 22 test the implementation procedure – refer to **APPENDIX C**. Knowledge about the implementation process was used to establish if it has conformed to either Liker's 13 step implementation procedure (2004:302), McGivern's and Stiber's (Undated:2) time frame implementation procedure or Shingo's (1990:224) one year implementation procedure. The identification of the relevant implementation procedure was possible as the questions pertain to all implementation procedures. The implementation procedures were different. Hence, the researcher was able to draw conclusions on the implementation method used. Having identified the relevant procedure, a comparison was done between practice and theory. This comparison will be discussed in Chapter five.

A key was developed for the analysis of respondent responses so that the researcher was able to distinguish between the different responses. This differentiation was deemed necessary since some of the respondents are operators, engineers and managers. Knowledge of the response from the various employees will help in the analysis as some information will be more readily available to managers as opposed to the operators.

Semi-structured interviews were used to allow the interviewer the ability to probe the interviewee's knowledge. Further advantages of interviews are the increased control over data collection as compared to other types of interrogation and the language used in the interview can be adjusted to suit respondent needs or education level (Cooper and Schindler, 1998:291).

Disadvantages of interviews are cost and respondents are reluctant to communicate with a stranger. Aspects associated with cost are money and time. Costs increase as the geographic spread of respondents increase. Travelling costs are now incurred in the interview process due to the geographic spread of respondents (Cooper and Schindler, 1998:291). The problem of cost was reduced since all respondents are at one location i.e. Smiths Manufacturing. The disadvantage of having a stranger as an interviewer was reduced as the interviewer works with the respondents. The presence of having a Smiths Manufacturing employee as an interviewer led to some degree of bias which cannot be avoided.

For the interview to be successful the respondent must be able to supply the needed information, the respondent must understand his or her role and the respondent must be motivated to co-operate (Cooper and Schindler, 1998:291). Respondent selection was based on a census. Hence, respondents were not pre-screened to ensure that they qualified to supply the needed information. The respondent qualification was based on the fact that they work on the line in which lean manufacturing was introduced. The role of the respondent was highlighted by the interviewer explaining the purpose of the study and by using probing questions to attain information. Respondent motivation was based on the fact that errors highlighted will be addressed, thus making their working conditions better.

Monitoring of the affected line condition before and after the introduction of lean manufacturing was used to assess its financial benefit. Areas monitored were space utilization, capacity, quantity of operators used, cost of stock, cost of work in progress and cost of lean manufacturing implementation.

3.4 RESPONDENT SELECTION

A census is defined as the count of all the elements in a population (Cooper and Schindler, 1998:215). Since all the people of the population involved in the implementation of lean manufacturing were interviewed, a census was done. The population involved consisted of 12 line workers, a quality engineer, a process engineer, a production engineer, a logistics engineer, a quality manager, a process-engineering manager, a logistics manager and a production manager.

Since a census was done, the respondents comprised of all the people involved in the lean manufacturing implementation i.e. 20 people. The 20 respondents comprised 12 line workers, four engineers and four managers.

3.5 DATA ANALYSIS

The data analysis followed three steps i.e. data preparation, data exploring, examining and displaying and data mining (Cooper and Schindler, 1998:411). This analysis was done on the data obtained from the interviews and the financial study. In order to reduce errors in data recording, all reporting forms were reviewed the same day. This "same day review" ensured that all shorthand notes and abbreviations were more accurately remembered. All interviews were voice-recorded to ensure easy reference for the researcher. Content analysis was used for the data analysis of the interviews. The units of the content analysis were syntactical and shown by words. Words were chosen since they are the smallest and most reliable unit. The keywords chosen reflected the research objectives for which the data were attained. A few general categories of keywords were chosen for the data analysis. Categories included knowledge of lean manufacturing, financial implications of implementing lean manufacturing and the effect of lean manufacturing on strategy. Once the phrase count was attained, generalizations were made regarding the implementation procedure (Mertens, 1998:355).

The data for the third research objective (i.e. to determine the financial benefit of lean manufacturing introduction on the respective assembly line) was analyzed by comparing the financial data before and after the lean manufacturing introduction. The impact of other stimuli (e.g. sales trends and breakdowns) on the financial calculations was reduced by concentrating only on areas that have been impacted by lean manufacturing i.e. space utilization, capacity, quantity of operators used, cost of stock and cost of work-in-progress. The difference in the values will determine if lean manufacturing has benefited the company or not. This value will be used to project the company's future competitive position and existence.

3.6 LIMITATIONS

The above-mentioned research design had a few limitations, which occured as a result of respondent frame, time and funding.

Respondents were limited to 20 individuals of whom 12 were workers, four were engineers and four were managers. This size poses problems as participation by the majority of them is vital for the study to be representative. People participation was encouraged by paying participants for their time. Participation is vital as the research involves a census and not a sample. Payment is a token of appreciation for respondent time, effort and inconvenience. Inconvenience was present in some cases as respondents had to find alternate means of transport home as interviews took place after work. Since it is not their fault for their loss in transport at the desired time, the researcher compensated the respondents to ensure that respondents participated in the interview. All respondents were paid R30 for their time.

According to Singer, Groves and Corning (1999:251), payment to respondents has no adverse effect on data quality. James and Bolstein (1990:346) have found that, in some instances, respondent response increases as incentives increase. Since financial constraints exist, the extent to which the people are available was limited, as the research is for academic purposes and is personally funded.

3.7 CONCLUDING REMARKS

Chapter Three describes the research methodology and tools used to obtain the relevant data for the research problem. In Chapter Four, the changes made to the 558N HVAC line will be discussed and financial implication will be assessed.

CHAPTER FOUR

RESULTS AND FINDINGS FROM QUANTITATIVE DATA ANALYSIS

4.1 INTRODUCTION

In Chapter Three, the data used in the research process were identified and the selection criteria highlighted. This research process was utilised to attain the quantitative data for the financial analysis in Chapter Four.

Chapter Four is divided into two sections. Section one focuses on the initial line change done in 2004 while section two focuses on the major line change done in 2005 and 2006. While the researcher does not draw conclusions, the reasons for the line changes as per the lean manufacturing implementation team are stated. The disclosure of the reasons is necessary as it sets the foundation for the analysis in Chapter Six and displays the thought process of the implementation team.

The financial reporting will focus on the effect of implementing lean manufacturing on raw material costs, labour costs, finished goods costs and implementation costs.

Overhead costs have been omitted as these are costed directly into the product. The major contributors to overhead costs include utilities, maintenance, rent, administration costs, depreciation, plant overheads, consumables, salaried costs, indirect costs and delivery vehicle charges.

These costs thus remain fixed as the final cost of the unit is agreed upon at the inception of the project (Stoltz, 2006).

In order to simplify the calculations of the financial impact of lean manufacturing, only 2006 costs will be considered. Considering present day costs eliminates the effect of:

- The fluctuating rand from 2004 to 2006 on the price of imported material;
- Current prices for material, labour and overhead;
- Changes in variant demand; and
- Comparisons between pre and post-lean implementation.

After the costs for each year were attained and tabulated, they were cumulated to show the net effect of lean implementation on the assembly line. When calculating the yearly costs, the following were considered:

- Each year is made up of 235 working days; and
- Each worker is paid for an eight-hour day but works 7.5 hours. The 0.5-hour is time lost due to lunch.

4.2 CHANGE ONE IN YEAR END 2004

Lean manufacturing was first introduced to the 558N HVAC line in 2004. Prior to the implementation of lean manufacturing to the line, the line had the following costs, as shown in **Table 4-1**:

Table 4-1: Costs for the 558N HVAC Line in 2004 Prior to Line Modification

ITEM	DETAILS	COST PER UNIT	NOTES
Number of operators	12	*R23.35 per person p/h	1
Number of line feeders	1	*R25.79 per person p/h	2
Supervisor	1	*R31 per person p/h	3
Cost of raw material on line (ALL 3 VARIANTS)	2 Days Stock (16 hours)	R251 113.5944 per 2 days (all variants)	4
Cost of finished goods in despatch (ALL 3 VARIANTS)	4 Days	R741 490.76 per 4 days (all variants)	5
Change over time * 2	60 Minutes	R305.86	6

Source: Self-Generated, 2006

The information and calculations in the above table are derived as follows. The number in the Notes column corresponds with the information relevant in the row.

Note 1, 2 and 3:
Refer to appendix A for pay rates of individuals

Note 4: Calculation for cost of raw material on line is:
All three variants have two days stock of raw material on line

- 2100-350-01 - Cost of two days stock of raw material
  - = (Cost of local material + cost of imported material per unit) * 2 * requirement per day
  - = (R759.2935 + R227.4873) [refer to Appendix A] * 2 * 16
  - = R31 576.9856 (a)

- 2100-351-01 - Cost of two days stock of raw material
  - = (Cost of local material + cost of imported material per unit) * 2 * requirement per day
  - = (R568.8240 + R225.9158) [refer to Appendix A] * 2 * 128
  - = R203 453.3888 (b)

- 2100-352-01 - Cost of two days stock of raw material

= (Cost of local material + cost of imported material per unit) * 2 * requirement per day

= (R200.3085 + R201.7720) [refer to Appendix A] * 2 * 20

= R16 083.22 (c)

- Therefore,, total cost of raw material on line for all 3 variants

= (a) + (b) + (c)

= R31 576.9856 + R203 453.3888 + R16 083.22

= R251 113.5944 (VALUE DEPICTED IN TABLE)

Note 5: Calculation for cost of finished goods in despatch

All three variants have four days stock of finished goods in despatch:

- 2100-350-01 - Cost of four days stock of finished goods

= Total Cost of finished goods * 4 * requirement per day

= R1 368.2509 (refer to Appendix A) * 4 * 16

= R87 568.0576 (a)

- 2100-351-01 - Cost of four days stock of finished goods

= Total Cost of finished goods * 4 * requirement per day

= R1 169.4824 (refer to Appendix A) * 4 * 128

= R598 774.9888 (b)

- 2100-352-01 - Cost of four days stock of finished goods

= Total Cost of finished goods * 4 * requirement per day

= R689.3461 (refer to Appendix A) * 4 * 20

= R55 147.688 (c)

- Therefore, total cost of finished goods in stores

= (a) + (b) + (c)

= R87 568.0576 + R598 774.9888 + R55 147.688

= R741 490.764 (VALUE DEPICTED IN TABLE)

Note 6: Calculation for Cost in Change over Time

The loss for a changeover can be looked at in terms of

- Loss in funds due to operators being paid for 0.5hrs of no value added. No value is added as line feeders are responsible for bringing the required parts to the line;
- Loss in number of units produced; and
- Loss in revenue due to no production being made. The costing of this loss will vary due to the customer's pack quantity (PQ) requirements. PQ requirements will affect the mix of variants built per hour hence, affecting costs.

In order to simplify calculations, the time lost for a changeover will be looked at in terms of loss in funds due to operators not being utilised and loss in units produced.

- **Loss in Number of units produced**

Score per hour is = Score per day/7.5hrs

= 225/7.5

= 30

Therefore, units lost in 0.5 hours are 15 units.

- **Loss in revenue**

Table 4-2: Pay Rate Table

POSITION	RATE
Supervisor	R31.00
Line Feeder	R25.79
Packer	R23.35
Quality Controller	R25.65
Operator	R23.35

Source: Self-Generated, 2006

The pay rates were attained from Govender (2006).

- Loss in revenue

= {(Hourly rate of operator * no. of operators * 0.5) + (Hourly rate of QC * 0.5)} * number of change over per day

= {(R23.35 * 12 * 0.5) + (R25.65 * 0.5)} * 2

= (R140.1 + R12.83) * 2

= R305.86

The rates for the line feeder, packer and supervisor have been excluded as they are utilised during the change over.

An understanding of the initial costs associated with the running of the line is important as the financial implication of lean manufacturing was determined by comparing the initial costs to the current (2005) costs i.e. after the implementation of lean manufacturing. Understanding of the costs also showed that when considering all three variants, material made up 26 percent of the total cost.

These costs are only recovered by Smiths Manufacturing when the completed HVAC assembly is sold. They are however, required, with imported parts to...

pay for the items before the items leave their suppliers' dock (Meikle, 2006a). It is therefore, necessary, according to Meikle (2006a), to keep as little raw material stock as possible due to the cost of the material.

4.2.1 AREAS OF CHANGE IDENTIFIED BY THE TEAM

In order to identify areas for lean manufacturing implementation, a team was developed. Members of the team included a process engineer, quality engineer, total industrial engineering (TIE) engineer, manufacturing manager, maintenance manager and TIE manager. The team leader was the TIE manager. The team with the help of a lean manufacturing consultant identified areas of waste with attention being focused on the highest waste contributors (Slack, 2006). Areas of waste highlighted by the team were:

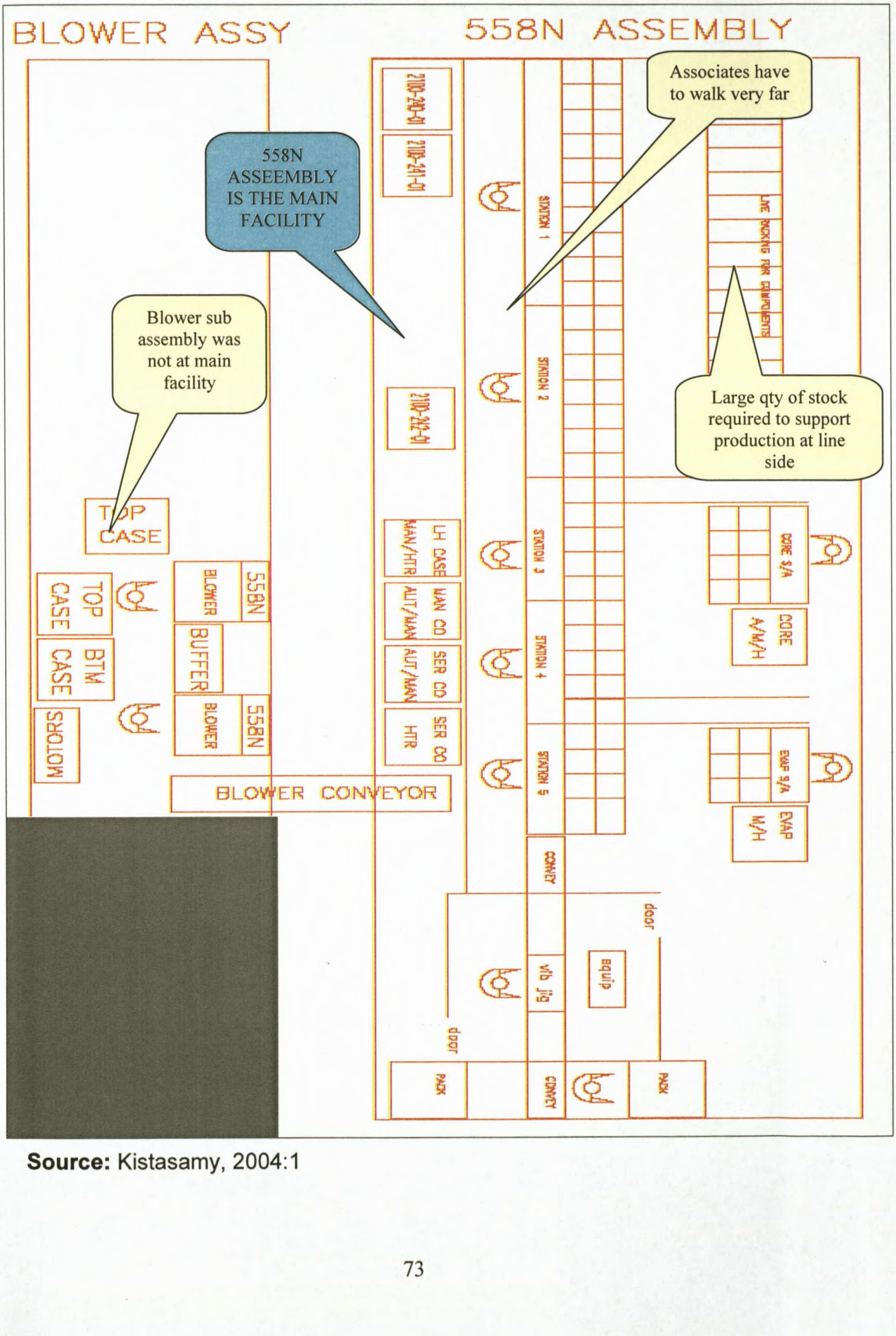
- Excessive stock on line, which resulted in the line being a temporary store. Some of this line-stock would have to be re-located during a change over when building the other two variants. A change over on the line entails the removal of uncommon bulk items such as plastic casings from the line and the re-location thereof. Smaller items such as screws and seals remain;
- Inefficient utilization of operators due to the line being too long. The long line further led to the unnecessary movement of the operators and the inefficient utilization of floor space and material, and
- Unnecessary movement of people to collect the blower assembly.

In order to reduce wastage in these two main areas, i.e. excessive stock and poor labour utilization, the team decided on relaying out the line that would address both concerns. The above areas of waste are shown in **Figure 4-1** and **Picture 4-1**, **Picture 4-2** and **Picture 4-3**.

Figure 4-1 provides a schematic layout of the current (2004) scenario with points that the team identified as areas of concern mentioned in 4.2.1. The bubbles show these areas of concern, viz.:

- The blower sub-assembly was not part of the main assembly line;
- Associates have too far to walk between stations, and
- Large quantity of stock is required to support production at the line side.

Figure 4-1: Depiction of Improvements (Current 2004 line layout with proposed changes)

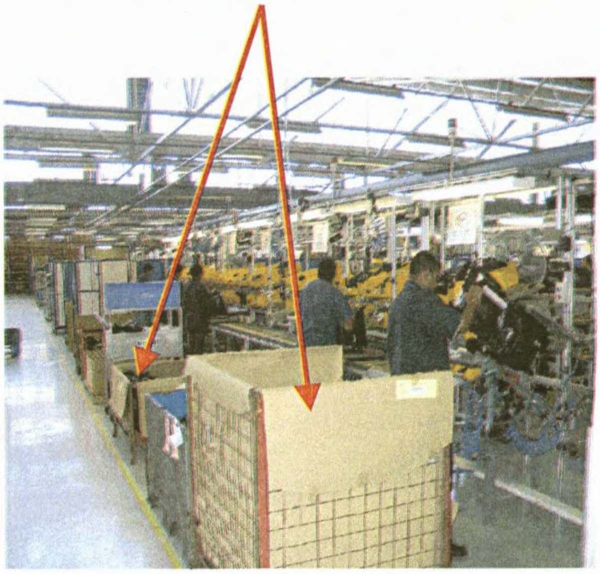


Source: Kistasamy, 2004:1

The concerns highlighted in **Figure 4-1** are evident with the pictures shown of stock-on-line. The blue trolleys, wire mesh cages and cardboard boxes in pictures one, two and three, respectively, are examples of excessive parts on line as parts present in these containers are packed to the top (Kistasamy, 2006).

Picture 4-1 – Blue Trolleys

Picture 4-2 – Wire Mesh cages

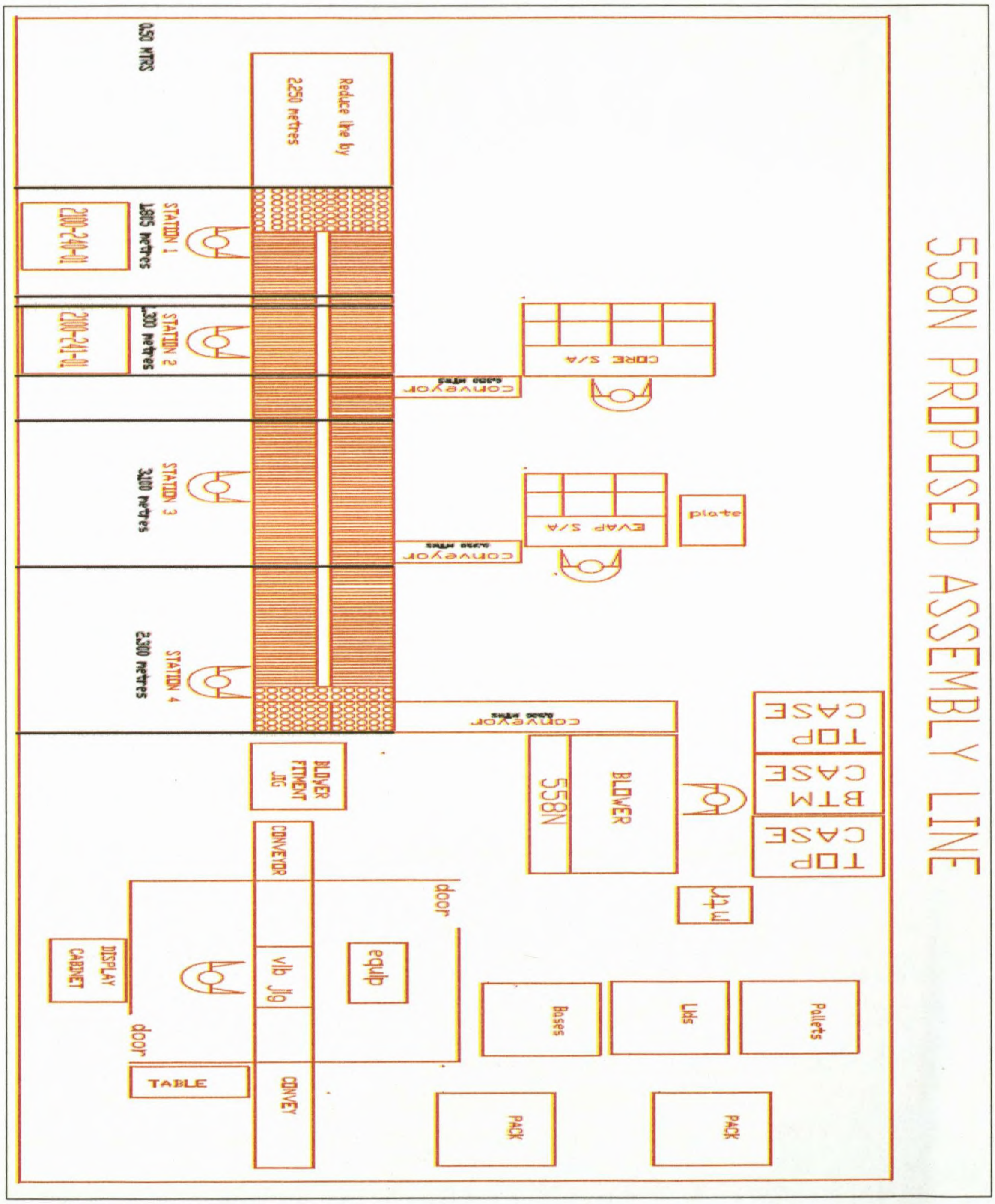


Picture 4-3: Cardboard Boxes

4.2.2 NEW LINE RELAY-OUT IN 2005 – CHANGE ONE

In order to reduce head count, stock-on-line and space utilised, the team decided to change the layout to the one shown below (Kistasamy, 2005).

Figure 4-2: Proposed new layout – 2005



Source: Kistasamy, 2005:1

The changes made to the existing 2004 layout were:

- The 558N Blower assembly line was included in the main assembly line as a sub-assembly;
- The length of the line was shortened by 2.5 metres; and
- Headcount had been reduced.

The differences between the existing (2004) and new (2005) line together with its corresponding financial implications are shown in **Table 4-3**.

Table 4-3: Changes Made to Line and Corresponding Financial Implications (2004 vs 2005)

ITEM	CURRENT – 2004		NEW - 2005		DIFFERENCE (A-B)	Notes
	Amount	Total (A)	Amount	Total (B)		
Daily Capacity	225	N/A	225	N/A	NO CHANGE	1
Line Space used	7.45m * 19m	141.55m²	7.45m * 16.5m	122.93m²	18.63m²	2
Operators used (Daily Total)	12	R2 241.60	8	R1 494.40	R747.20	3
Line feeders (Daily Total)	1	R206.32	2	R412.64	-R206.32	4
Raw Material on line	16 hours	R251 113.59	5 Hours	R78 472.99	R172 640.59	5
Change over time (3 per day)	1.5 hours	R458.78	Negligible	0	R458.78	6
Material required to change line	0	0	Various items	R500	- R 500	7
Labour required to change line	0	0	14 hours	R3000	- R3 000	8
Dunnage Required for new batch sizes	0	0	180 pieces	R7960	- R7 960	9

Source: Self-Generated, 2006

The information and calculations in the above table are derived as follows. The number in the Notes column corresponds with the information relevant in the row.

Note 1: Daily Capacity

- Attained through personal communication with Slack (2006).

Note 2: Line Space Used

- Attained through personal communication with Govender (2006)

Note 3: Operators used (Daily Total)

- Operators used (Daily Total 2004) = Number of operators * hourly rate * hours worked per day
  = 12(Slack, 2006) * R23.35 (Refer to Appendix A) * 8
  = R2 241.60

- Operators used (Daily Total 2005) = Number of operators * hourly rate * hours worked per day
  = 8 (Slack, 2006) * R23.35 (Refer to Appendix A) * 8
  = R1 494.40

Note 4: Line feeders (Daily Total)

- Line feeders (Daily Total) current 2004
  = Number of line feeders * hourly rate * hours worked per day
  = 1(Slack, 2006) * R25.79 (Refer to Appendix A) * 8
  = R206.32

- Line feeders (Daily Total) new 2005
  = Number of line feeders * hourly rate * hours worked per day
  = 2(Slack, 2006) * R25.79 (Refer to Appendix A) * 8
  = R412.64

Note 5: Raw Material on line

- Raw material on line current 2004 = from table 4.1.

- Raw Material on line new 2005 = {(Raw Material on line current 2004)/16} * 5 days
  = (R251 113.59/16) * 5
  = R78 472.99

Note 6: Change over time

- Cost for change over time (current 2004 – Daily saving)
  = lost rands due to operators being paid for zero products being produced
  = {(Hourly rate of operator * no. of operators) + (Hourly rate of QC)} * change over time
  = {(R23.35 [Refer to Appendix A] * 12) + (R25.65 [Refer to Appendix A])} * 1.5
  = (R280.20 + R25.65)* 1.5
  = R458.78

- Cost for change over time (new 2005) is negligible.

Note 7: Material required to change line

- Material required to change line are as per Jevon (2006).

Note 8: Labour required to change line

- Labour required to change line are as per Jevon (2006).

- **Note 9: Dunnage Required For New Batch Sizes – new 2005:**

Table 4-4: Dunnage Cost

DUNNAGE			
Type	**Unit Cost**	**Qty**	**Total**
Large Lin Bins	R 90	30	R 2,700
Medium Lin Bins	R 68	20	R 1,360
Small Lin Bins	R 15	100	R 1,500
Correx Bins	R 80	30	R 2,400
	GRAND TOTAL		R 7,960

Source: Self-Generated, 2006

Dunnage costs and quantities attained from Venkadu (2006).

Further to changes on the line, changes have also been made with stock in despatch. Stock-holding has reduced from four days to 1.5 days. The reduction in stock-holding is possible due to the reduction of change over time, which allows each variant to be built during the same day. The financial implication of stock reduction across the three variants is shown in **Table 4-5**:

Table 4-5: Effect on Despatch Due to Change One in 2005

Variant	Unit Cost	4 Days stocking policy 2004		1.5 Days stocking policy 2005		DIFFERENCE (A-B)
		Qty of Units	Total Cost (A)	Qty of Units	Total Cost (B)	
2100-350-01	R1 368.25	64	R87 568.00	24	R32 838.00	R54 730.00
2100-351-01	R1 169.48	512	R598 773.76	192	R224 540.16	R374 233.60
2100-352-01	R689.35	80	R55 148.00	30	R20 680.50	R34 467.50

Source: Self-Generated, 2006

Note:

- Refer to Appendix B for Unit Cost of variants.
- Quantity of units attained from Pillay (2006)

For companies to attain the full benefit of lean manufacturing, they need to utilize all its tools. One of the tools of lean manufacturing or the Toyota Production system is Kaizen i.e. to continuously improve (Kitano, 1997:4). Changes in the 558N HVAC line had been made and improvement noted but the company had to improve further in order to attain further benefit. The second major change started in mid-2005.

4.3 CHANGE TWO IN 2005

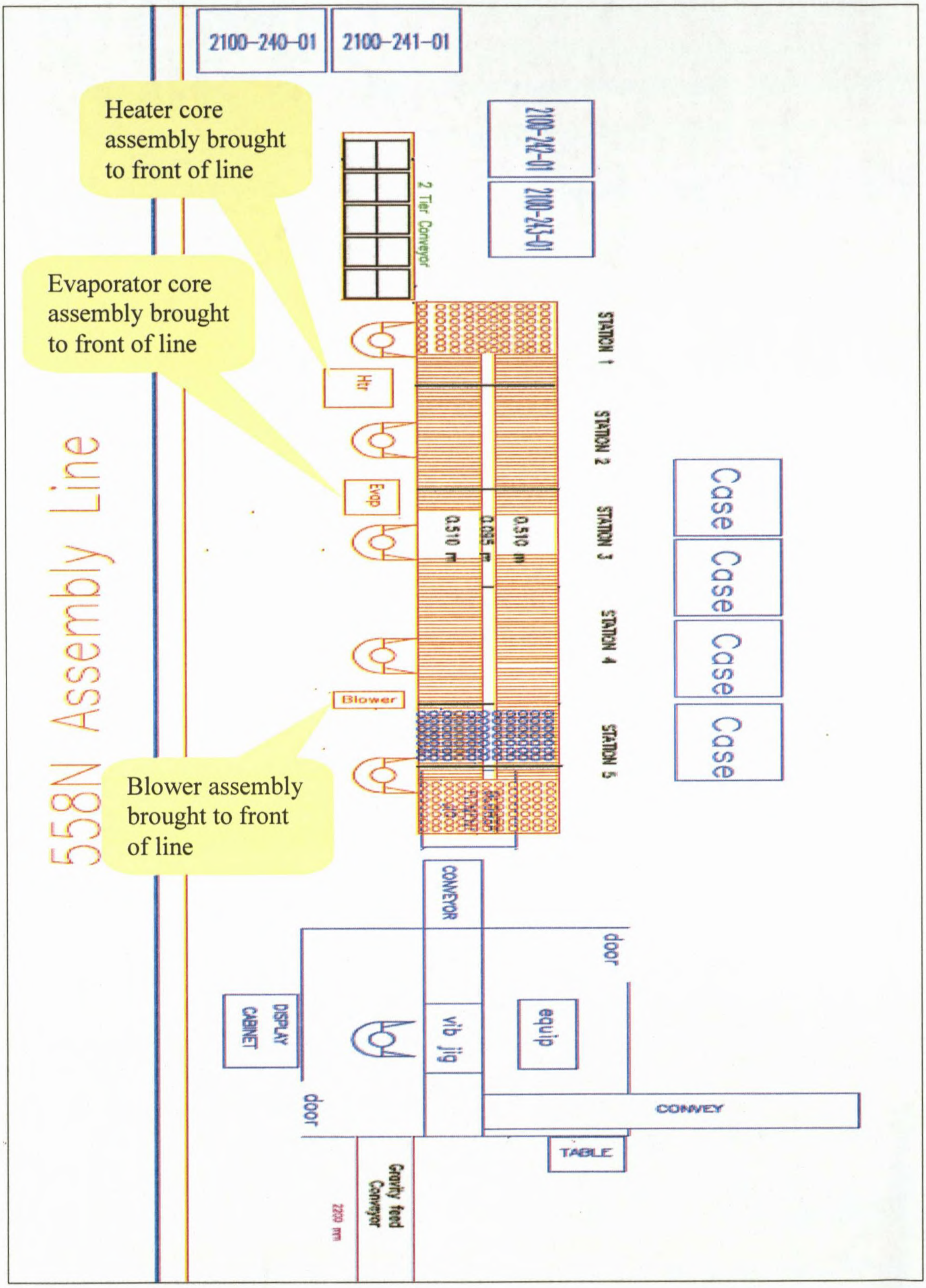
Further improvements were made to the line in 2005 with the aid of assistance from people from Toyota Japan. These Toyota employees, together with the original team formed by Smiths Manufacturing, continued to focus on:

- Line layout which impacted on operator movement and flexibility;
- Raw material stock; and
- Finished goods stock (Slack, 2006).

4.3.1 LINE RE-LAYOUT IN 2005

The team decided to improve line layout by removing all sub-assemblies from the rear of the line and added them to the front. The sub-assemblies that moved from the rear of the line were the evaporator core assembly, heater core assembly and blower assembly (Kistasamy, 2006). This change is evident in **Figure 4-3** where the sub-assembly lines moved are referenced by the yellow text boxes. This change occurred at the end of 2005 with production starting on the new line in 2006.

Figure 4-3: Proposed New Layout for 2005 – Change Two



Source: Kistasamy, 2005:1

The movement of the evaporator sub-assembly, heater core sub-assembly and blower sub-assembly eliminated the need for batch building as the operator was now forced to build one for one. The production of one part at a time resulted in a reduction in head count by one person with increased flexibility. Flexibility in the line, according to Slack (2006), is the ability to change the number of operators used. Flexibility allows the line to adjust to a change in customer demand in a shorter span of time.

4.3.2 RAW MATERIAL STOCK

The changes in the layout of the line coupled with the introduction of increased Kanban deliveries to the line have enabled line stock to be reduced from five hours to 0.67 hours. Stock is now delivered in shopping baskets where a set number of parts are delivered for 0.67 hours of production.

The differences between the existing 2005 line and new 2006 line together with its corresponding financial implications are indicated in **Table 4-6**.

Table 4-6: Changes made to Line and Corresponding Financial Implications – Change Two in 2005 vs Change in 2006

ITEM	CURRENT – 2005		NEW - 2006		DIFFERENCE (A-B)	NOTES
	Amount	Total (A)	Amount	Total (B)		
Daily Capacity	225	0	225	0	NO CHANGE	1
Line Space used	7.45m * 16m	122.93m²	7.45m * 16m	122.93m²	0	2
Operators used (Daily Total)	8	R1 494.40	7	R1 307.60	R186.80	3
Line feeders (Daily Total)	2	R412.64	2	R412.64	0	4
Raw Material on line (Daily Total)	5 hours	R78 472.99	0.67 Hours	R10 515.38	R67 957.61	5
Change over time (Daily)	Negligible	0	Negligible	0	0	N/A
Material required to change line	0	0	Various	R1 000	-R1 000	6
Labour required to change line	0	0	20 hours	R5 000	- R5 000	7
Dunnage Required for new batch sizes	0	0	62 pieces	R6 570	- R6 570	8

Source: Self-Generated, 2006

The information and calculations in the above table are derived as follows. The number in the Notes column corresponds with the information relevant in the row.

Note 1: Daily Capacity

- Attained through personal communication with Slack (2006).

Note 2: Line Space Used

- Attained through personal communication with Govender (2006)

Note 3: Operators Used

- Operators used (Daily Total 2005)

  = No. of operators * Rate * Daily hours paid for

  = 8 (Slack, 2006) * R23.35 (Refer to Appendix A) * 8

  = R1 494.40

- Operators used (Daily Total 2006)

  = No. of operators * Rate * Daily hours paid for

  = 7(Slack, 2006) * R23.35 (Refer to Appendix A) * 8

  = R1 307.60

Note 4: Line Feeders Used

- Line feeders used (Daily Total 2005/2006)

  = No. Of line feeders * Rate * Daily hours paid for

  = 2(Slack, 2006) * R25.79 (Refer to Appendix A) * 8

  = R412.64

Note 5: Raw material on line

- Raw Material on line current 2005 = from table 4.2.
- Raw Material on line new 2006 = {(Raw Material on line current 2005)/5} * 0.67

  = (R78 472.99/ 5) * 0.67

  = R10 515.38

Note 6: Material required to change line

- Material required to change line are as per Jevon (2006).

Note 7: Labour required to change line

- Labour required to change line are as per Jevon (2006).

- **Note 8: Dunnage Required For New Batch Sizes – new 2006:**

Table 4-7: Dunnage Cost

DUNNAGE			
Type	**Unit Cost**	**Qty**	**Total**
Correx type 1	R240	16	R3,840
Correx type 2	R70	10	R700
Correx type 3	R140	12	R1,680
Lin Bin type 1	R40	2	R80
Lin Bin type 2	R15	12	R180
Lin Bin type 3	R9	10	R90
	GRAND TOTAL		R6,570

Source: Self-Generated, 2006

Dunnage costs and quantities attained from Venkadu (2006).

4.4) CONCLUDING REMARKS

The chapter focused on the initial setup of the line in 2004 followed by the corresponding changes in 2004 and 2005. The impact of these changes has been tabulated to facilitate the comparison. Further changes have been done in 2006 and the comparison made between 2006 and 2005.

The effect of these changes in 2004, 2005 and in 2006 on the company's bottom line will be analysed in Chapter Six. Chapter Five will pertain to the data attained from the personal interviews.

CHAPTER FIVE

RESULTS: QUALITATIVE DATA FROM PERSONAL INTERVIEWS

5.1 INTRODUCTION

This chapter reports the research findings from the personal interviews. No qualitative data is available from focus groups as this method of data collection was not possible due to the logistics involved in interviewing the relevant people at a specified time and location. The major contributor to this problem was the working of excessive overtime which was needed to meet increasing customer demands, cater for material shortages which resulted in the line stopping production and machine breakdowns (Meikle, 2006b).

In order to cater for the loss of data from the operator focus groups, in-depth personal interviews were conducted with the operators. Personal interviews enabled the researcher to continue with the research, as the interview was now only dependant on one individual being at a designated place and time as opposed to six people. All interviewees, while interviewed at different times, were interviewed in the same location in order to ensure standardization with respect to surroundings. The location was a closed boardroom to ensure no outside interference and noise. Prior to conducting the interview, interviewee receptiveness was increased by explaining the purpose of the study (see Appendix D-1 for advisement letter), advising them to be honest in their answers, ask if they were uncertain about any questions and that there are no wrong answers (Cooper and Schindler, 1998:293).

A total of 39 questions were analysed. Some respondents were asked all 39 questions whereas others weren't, due to their inherent knowledge and the nature of the interviews i.e. semi-structured. Analysis of the questions was broken up into two main sections.

Section one consisted of 17 questions and was broken up into two sub-sections viz., general knowledge about lean manufacturing and knowledge about lean manufacturing's impact on the company's financial and competitive position.

Section two consisted of 22 questions which focused on determining the manner in which lean manufacturing was introduced in Smiths Manufacturing. Knowledge about the implementation process was used to establish if it had conformed to either Liker's 13 step implementation procedure (2004:302), McGivern's and Stiber's (Undated:2) time frame implementation procedure or Shingo's (1989:224) one-year implementation procedure. After identifying the relevant procedure, a comparison was done between actual and theory.

5.2 KNOWLEDGE

5.2.1 KNOWLEDGE ABOUT LEAN MANUFACTURING

Holistically, employee knowledge of lean manufacturing on the 558N HVAC line at Smiths Manufacturing is limited with the average score of ten employees (45 percent). It was noticed that knowledge level varied among the operators, engineers and manager. The average score for operators was 37 percent, 47 percent for engineers and 71 percent for managers – (Appendix C

– Personal Interview Questions and Responses). The low score for operators could be attributed to the lack of training received by the employees at lower levels. Five of the eight respondents had not received training on the lean manufacturing system. Therefore, they had limited knowledge of the system. Many respondents (five out of seven) suggested that the training skills led to an improvement when implementing lean manufacturing on other lines.

The lack of training resulted in the people not fully understanding the concept of TPS. This lack of understanding is evident when the respondents' knowledge of the systems that make up lean manufacturing was tested. The average score was 19 percent. The respondents, while not being able to identify the systems that made up lean manufacturing or TPS, were able to define them. Respondents' knowledge, with regards to the definitions of the lean manufacturing system, averaged 74 percent. This high score was due to their daily interaction with these "buzz" words.

Average respondents' knowledge while "poor" is supported by certain implementation procedures that provide training after the introduction of the system. Learning by doing is a suggested form of educating oneself (Liker, 2004:303).

5.2.2 KNOWLEDGE ABOUT LEAN MANUFACTURING'S IMPACT ON THE COMPANY'S FINANCIAL AND COMPETITIVE POSITION

Analyses of respondent responses showed that the company has not made available any figures with regards to the financial benefit or drawback of lean manufacturing. All statements made by the respondents, which either support or reject the financial benefit of lean manufacturing, are, therefore, based on perception.

Nine out of ten respondents agreed on the continuation of lean manufacturing implementation on other lines. The main driver for this seems to be that six of the eight respondents felt that the implementation improved the financial gain of the company. This point is further discussed in Chapter Six, where quantitative analysis supports this statement.

The implementation of lean manufacturing is also believed to have increased the competitiveness of the company with all eight respondents agreeing to this. Engineers provide examples of lean manufacturing improving process efficiency to enable employees to build products at a cheaper rate. The cheaper manufacture of products helps reduce the selling price which improves the competitiveness of the company.

5.3 LEAN MANUFACTURING IMPLEMENTATION PROCEDURE

Three types of lean manufacturing implementation procedures were identified i.e. Liker's 13-step implementation procedure (2004:302), McGivern's and Stiber's (Undated:2) time frame implementation procedure and Shingo's (1990:224) one-year implementation procedure. Analysis of the responses revealed that Smiths Manufacturing share similarities with all three procedures with the highest similarity being with Liker's 13-step implementation procedure.

In order to aid analysis, Liker's 13-step procedure will be stated with Smiths Manufacturing's adherence or lack thereof discussed. This comparison will show the variance between Liker's theory and Smiths's practice.

- Begin with changes/improvements in the technical systems followed by cultural change. Leaders must be actively involved in the system implementation as this will assist cultural change;
  - Senior management have been actively involved with 90 percent (nine out of ten respondents) of the respondents agreeing that Smiths Manufacturing has followed a top down approach – supports Liker's implementation procedure.

- Learn by doing first and training second. The idea of doing first is to allow people to identify problems and develop their own solutions hence, learning by doing. According to Liker (2004:302), the ratio of doing to learning is 80 percent doing to 20 percent learning;
  - Many respondents have complained about the lack of training with six of the eight respondents advising that they had gone for training after the introduction of lean manufacturing. Training after the introduction of lean manufacturing supports Liker's implementation procedure.
- Implement lean manufacturing on one line first so that employees can see the benefits of the system;
  - 80 Percent of the respondents agree to Smiths Manufacturing introducing lean manufacturing on one line first. This view

supports Liker's implementation. Some responses have indicated that Smiths Manufacturing have tried implementation on multiple lines with the one customer being in focus. These implementation procedures are still being considered as one line, since they share a common customer.

- Plot material and information flow diagrams of actual occurrences. Plotting the path of a part from start to finish helps the team collectively see and identify areas of waste;
  - Respondents were unable to identify the material flow chart as being the method of waste identification. A common method used was visual identification. Visual identification is contrary to what was discussed with the engineer as a material flow chart was obtained from the engineer for the 558N HVAC line – Section 2.4.2.2, **Figure 2-16**. It is therefore, assumed that the people questioned were not responsible for the generation of the document.

- Continuous improvement workshops should be held to teach employees to identify areas of improvement. Once these areas have been identified, the implementation of these improvements must be accelerated;
  - The majority of the respondents feel that Smiths Manufacturing encourage the generation of bright ideas through their incentive schemes, thus adhering to Liker's implementation plan.

- Have one manager that is responsible for the entire lean implementation process. The management structure during this implementation procedure will be that of a matrix organization;
    - Discussions with the respondents have revealed that while one manager has not been identified, one division, viz., Total Industrial Engineering has been identified. Since one division has been identified, it is assumed that one manager is responsible for driving lean manufacturing implementation, which supports Liker's implementation procedure.

- Ensure that lean manufacturing is mandatory and consequences exist for not adhering to the implementation time table;
    - This point has not come forth from discussions with the respondents. Therefore, this aspect may be an item for future research.

- Leadership must be focused on long-term improvement;
    - This point has not come forth from discussions with the respondents. Therefore, a conclusion cannot be drawn on its adherence or lack thereof to Liker's implementation procedure. Improvements are encouraged but the time frame is not stipulated as the company sees improvements as ongoing.
- Choose lines that will be able to show the financial benefits of lean manufacturing. This financial gain will be used to sell the system and attain a buy-in from other members in the organization;

- While Smiths Manufacturing may have chosen a line that is able to show the financial benefits, none of these benefits have been divulged to the people. Some respondents are aware of the benefit but none have seen a formal document pertaining to the savings or cost of lean manufacturing. All four respondents agreed that the absence of a cost benefit analysis will hinder the implementation of lean manufacturing as it reduces peoples' acceptance. It may be concluded that Smiths have not complied with Liker's implementation procedure for this point.

- Break away from traditional measurements and measure those aspects that add value to becoming a lean organization;
    - One type of measurement to break away from is daily score. While it is important, it is not critical to a lean organization as production stops once stock levels reach a certain value. The stopping of production once stock levels have been achieved has not come forth from the interviews. All respondents however agreed that batch building is bad. Data received from the interviews are insufficient to conclude that Smiths Manufacturing is adhering to this method of production. Future research will be needed to address this point.
- Modify the lean manufacturing system to meet the needs of the company.
    - Modifying the lean manufacturing system to meet the needs of the company is evident with Toyota who has called lean manufacturing the Toyota Production system. There was no

need for Smiths to modify the system to meet the needs of the company as both Toyota and Smiths Manufacturing are both in the automotive industry. Smiths has, however, failed to own the system as they are still calling it the Toyota Production System i.e. TPS and some of the respondents referred to it as such. Liker advises that a company needs to build on its own heritage (2004:306). Hence, this is an area where Smiths Manufacturing has not conformed to Liker's implementation procedure.

- Top management need to understand the system so that it can be driven top-down; and
  - Analysis of the scoring for respondent knowledge indicated that as seniority increases so to does knowledge, which supports Liker's statement. Management has attained 71 percent for general knowledge pertaining to lean manufacturing.

- If management don't have a sound understanding, a lean manufacturing expert must be hired.
  - Analysis of the responses has shown that Smiths Assembly tried to train the necessary people to introduce lean manufacturing. They have received assistance from Toyota. Toyota has served as the expert for guidance.

Based on the above, it may be concluded that Smiths Manufacturing have implemented eight of Liker's 13-step implementation plan. 100 percent adherence is assumed based on the majority of the respondents' responses. Information was insufficient to deduce that Smiths Manufacturing have conformed to three of the above mentioned steps. This aspect should be subject to research.

The remaining two steps were concluded as areas of non-conformance. The two areas were the absence and disclosure of a financial analysis and the lack of owning the system.

The absence of a financial analysis during the early phases of lean implementation reduces buy-in from management. It is because of this lack of buy-in from management that Liker (2004:305) recommends doing the analysis to have a 100 percent chance of impressing management.

According to Liker, implementing the lean system is not as beneficial as owning the system. Owning the system brings about sustainability as it involves a culture change (Liker, 2004:12). Liker users the 4P model (Liker, 2004:13) to highlight that process improvements are only one aspect of the 4Ps. Philosophy, people and partners and problem solving are vital to see the true benefit of lean manufacturing. Smiths Manufacturing, therefore, need to change the name of TPS so that it encompasses Smiths ownership of the system. The ownership of the system should help in living the philosophy and growing the lean manufacturing culture within the organization.

5.4 CONCLUSION

Chapter Five focused on respondent knowledge of lean manufacturing, its impact on the company's financial and competitive position and Smiths Manufacturing's implementation procedure of the system.

Average respondent knowledge is 37 percent, with average knowledge increasing for engineers and managers. Many respondents are of the opinion that the implementation of lean manufacturing has benefited the company financially with none of them having seen an actual financial analysis. Respondents also feel that the company's competitiveness has been increased as a result of the implementation.

Smiths Manufacturing has conformed to Liker's 13-step implementation plan with eight of the 13 steps being followed. Insufficient respondent information had been available to determine if three of the 13 steps conformed to theory. This shortcoming can be addressed in future research.

In order to attain a better understanding of lean manufacturing in the company, further research should be done where many production lines are considered. Consideration of additional production lines will help increase respondent quantity, which can better cater for non-willing participants and provide a more representative average. An increase in management participation will help determine if all management have a good understanding of the system. The participation of management and the information attained is vital as theory requires that management have an in-depth knowledge of lean manufacturing since they are implementing the system.

A greater deal of focus also needs to be placed on the culture of the organisation as Liker (2004:12) advises that a culture that encourages lean manufacturing is the main success factor of a lean organisation. This assessment should not be restricted to the production environment but should include all divisions e.g. finance, human resources and information technology. Inclusion of all divisions will help create an overall picture of the company as a lean organisation.

The following chapter, viz., Chapter Six will discuss the financial effect of implementing lean manufacturing on the 558N HVAC line.

CHAPTER SIX

FINANCIAL ANALYSIS ON THE IMPACT OF LEAN MANUFACTURING ON THE 558N HVAC LINE

6.1 INTRODUCTION

Chapter Six analyses the financial impact of the two major changes done in 2005 and 2006. The financial impact of both changes for both years will be combined in order to determine the effect of lean manufacturing on the company's operating leverage. The operating leverage will be calculated specifically for the line being evaluated i.e. the 558N HVAC line. Operating leverage, according to Gitman (2000:489), is the relationship between the company's sales income and its earnings before interest and tax i.e.

Operating Leverage:

= Sales revenue – fixed operating expenses – variable operating expenses

= Earnings before interest and tax (EBIT) (Gitman, 2000:491)

According to Stoltz (2006), the fixed operating expenses remain unchanged for the year. Therefore, EBIT changes by increasing sales or decreasing variable operating expenses. Lean manufacturing focuses on the operating expenses (What is the Theory of Constraints, and How Does it Compare to Lean Thinking? 2007:1). The operating expenses evaluated in Chapter Four are raw materials, labour, finished goods and implementation costs.

The assessment of the evaluated operating expenses will help in:

- Determining the financial impact of lean manufacturing on this assembly line; and
- The impact of lean manufacturing introduction to Smiths Manufacturing's competitive position and future existence.

6.2 IMPACT ON LABOUR COSTS

The effect of lean implementation on operators and line feeders is easiest understood by looking at the tabulated changes from 2004 to 2006 as depicted in **Table 6-1** i.e. Cumulative Head Count. The cumulative values have been attained from **Tables 4-2** and **4-5** that were discussed in sections 4.2.2 and 4.3.2 of Chapter Four.

Table 6-1: Cumulative Yearly Headcount

ITEM	CURRENT - 2004		2005		Difference (2004-2005)	Yearly Effect	NEW - 2006		Difference (2005-2006)	Yearly Effect
	Amount	Total (A)	Amount	Total (B)	(A-B)		Amount	Total (C)	(B - C)	
Operators used (Daily Total)	12	R2 241.60	8	R1 494.40	R 747.20	R 174,844.80	7	R1 307.60	R 186.80	R 43,711.20
Line feeders (Daily Total)	1	R 206.32	2	R 412.64	-R 206.32	-R 48,278.88	2	R 412.64	R 0.00	R 0.00

Total savings (2004 to 2005) = R 126,565.92 (1)

Total savings (2005 to 2006) = R 43,711.20 (2)

TOTAL SAVINGS (2004 to 2006) = (1) + (2)
R170 277.12

Source: Self-generated, 2006

Notes:

Current 2004 and 2005 costs attained from Table 4-2

New – 2006 costs attained from Table 4-5

Operator head count had decreased from 12 in 2004 to eight in 2005 while line feeder headcount had changed from one to two. The cumulative effect of these changes in headcount had led to a saving of R126 565.92.

From 2005 to 2006, the headcount was slightly less with operator head count changing from eight to seven and line feeder headcount remaining unchanged. The net effect of the change in operator head count led to a cumulative saving of R43 711.20.

The implementation of lean manufacturing from 2004 to 2006 led to contributing a further R170 277.12 to the bottom line of the 558N HVAC over the two-year period. This saving re-enforces the benefits of lean manufacturing on labour utilization as discussed in section 2.3.3 of Chapter Two. This was possible through the continuous improvement of the line from 2004 to 2006. According to Zimmer (2000:4), it is these ongoing improvements that optimise the process which result in such savings. These savings were highlighted by discussions with engineers in Chapter Five.

This is the minimum saving as the company subsidizes medical aid and provident fund contributions. Medical aid contributions have been neglected because it is not compulsory for operators to take medical aid. Hence, savings cannot be combined over the total number of operator reductions.

6.3 IMPACT ON RAW MATERIAL COSTS

Raw material consists of local and imported material. All raw material is fed to the line via stores. Stores have a stock holding policy of three days for local material and one month for imported material (Chetty, 2006). The number of days for stock holding varies between local and imported material due to the delivery time. The maximum lead-time for local material delivery is two days as opposed to one month for imported material. The main contributor to the month lead-time for imported material is the mode of transport used, viz., sea freight. Sea freight is the chosen means of transport as opposed to airfreight due to cost implications (Denichand, 2006). Since the store's stocking policy has not yet changed for imported and local parts, no saving will be present on material purchased.

Changing the quantity of raw material on the line will affect frequency of deliveries to the line and change over time. The reduction in raw material on line from 2004 to 2005 led to the increase in material deliveries to the line. Hence, an additional line feeder was hired (as shown in **Table 4-2** of Chapter Four). Two line feeders have since been retained from 2005 to 2006 (as shown in **Table 4-5**). The costs associated with the line feeder from 2004 to 2006 have been considered in the Labour Costs (6.2 above).

While reducing the stock on line has led to the cost of an additional line feeder for R48 278.88, it has led to a decrease in change over time. Change over time has decreased from 1.5 hours per day in 2004 to nearly zero in 2005 and

2006 as shown in **Table 4-5**. Yearly savings for change over time from 2005 and 2006 equate to:

Savings per day	=	R458.78	(see **Table 4-2**)
Savings per year	=	savings per day * working days per year	
	=	R458.78 * 234	
	=	**<u>R107 813. 30 per year</u>**	

Thus, total savings from raw material reduction on line is **R215 626.60** for the period from 2005 to 2006. The reduction of raw material on line conforms to the JIT principle as discussed in Section 2.3.2.2 of Chapter Two which, in turn, led to witnessing the benefit of lean manufacturing implementation.

6.4 IMPACT ON FINISHED GOODS

Table 6-2 indicates that the stocking policy of finished goods has changed from four days in 2004 to 1.5 days in 2005. This reduction in stock has reduced the rand amount of finished goods by R463 431.10.

Table 6-2: Rand Value of Finished Goods Stock

Variant	Unit Cost	4 Days stocking policy 2004		1.5 Days stocking policy 2005/2006		DIFFERENCE
		Qty of Units	Total Cost (A)	Qty of Units	Total Cost (B)	(A-B)
2100-350-01	R1 368.25	64	R 87,568.00	24	R 32,838.00	R 54,730.00
2100-351-01	R1 169.48	512	R 598,773.76	192	R 224,540.16	R 374,233.60
2100-352-01	R 689.35	80	R 55,148.00	30	R 20,680.50	R 34,467.50
TOTAL STOCK HOLDING			R 741,489.76		R 278,058.66	
	TOTAL SAVING		**A**	**-**	**B**	
		=	**R 463,431.10**			

Source: Self-Generated, 2006

Note:

- Refer to Appendix B for Unit Cost of variants.
- Quantity of units attained from Pillay (2006)

While the rand amount of finished goods has changed, the saving is purely in labour utilization, quality and space as Smiths is still keeping the same amount of raw material.

The saving in labour utilization from 2004 to 2006 is R1 266.16, as shown in **Table 6-3**.

Table 6-3: Total Labour Utilization Saving

LABOUR UTILIZATION SAVING

		Notes
Units required for 4 day stocking policy - 2004	656	(1)
Units required for 1.5 day stocking policy- 2006	246	(2)
Difference in Units **(A)**	410	(3)
Available production capacity per day 2004 and 2006	225	(4)
Days required to produce **(A)**	1.82	(5)
Hours Required	13.92	(6)
Labour cost in 2004 to produce 410 units	R 4,259.38	(7)
Labour cost in 2006 to produce 410 units	R 2,993.22	(8)
Saving	**R 1,266.16**	(9)

Source: Self-Generated, 2006

The information and calculations in the above table are derived as follows. The number in the Notes column corresponds with the information relevant to the row. The assumption is that once the stocking policy has been attained, units produced thereafter will match customers demand. Hence, there is no need to work additional hours to replenish "safety stock" present in stocking policy. It is because of this that the saving is once off for the year

Note 1: Units required for four day stocking policy:

= Σ (4 day requirement for 2100-350-01, 2100-351-01 and 2100-352-01)

= 64 + 512 + 80

= 656

Note 2: Units required for 1.5 day stocking policy:

= Σ (1.5 day requirement for 2100-350-01, 2100-351-01, 2100-352-01)

= 24 + 192 + 30

= 246

Note 3: Difference in units

= Units required for four day stocking policy - Units required for 1.5 day stocking policy

= 656 – 246

= 410

Note 4: Available production capacity per day

- Attained through personal communication with Slack (2006).

Note 5: Days required to produce (A)

= Difference in units/ Available production capacity per day

= 410/225

= 1.82

Note 6: Hours required

= Days required to produce (A) * hours worked

= 1.82 * 7.65

= 13.92 hours

Note 7: Labour cost in 2004 to produce 410 units

= {[(No of operators * rate per operator) + (No of line feeders * rate per packer)] * days needed to build requirement}
= {[(12 * R23.35) + (1* R25.79)] * 13.92}

= {[R280.20 + R25.79] * 13.92}

= R4 259.38

Note 8: Labour cost in 2006 to produce 410 units

= {[(No of operators * rate per operator) + (No of line feeders * rate per packer)] * days needed to build requirement}
= {[(7 * R23.35) + (2* R25.79)] * 13.92}

= {[R163.45 + R51.58] * 13.92}

= R2 993.22

Note 9: Saving

= Labour cost in 2004 to produce 410 units - Labour cost in 2006 to produce 410 units

= R4 259.38 - R2 993.22

= R1 266.16

Savings for space offers no monetary gain if the existing area is unutilised. The savings from quality arise as there is a smaller amount of finished goods to rework if a quality defect is present. These areas of saving are similar to the research conducted by Nist Manufacturing extension Partnership (Kilpatrick, 2003:3) as identified in Chapter 2, Section 2.3.3.

6.5 IMPLEMENTATION COSTS

The implementation of lean manufacturing on the 558N assembly line resulted in changes being made to the production line. These changes were necessary to cater for the reduction in headcount, reduce wasted operator motion and incorporate line improvements to the line (Jevon, 2006).

Changes occurred in the form of cutting and reducing line size and the manufacture of new line side racking which would be able to house new dunnage. Reduction in line length reduces operator movement and encourages one to one production. A shorter line has less space for large quantities of parts on line, thus forcing parts to be delivered in smaller quantities, which require new dunnage. The delivery of parts in smaller quantities reduces change over time, as bins are "bled dry" before changing to another variant. This re-designing of the process has led to flexible manufacturing (George and Jones, 2006:282) as discussed in Chapter 2, Section 2.3.2.8. The benefit of flexible manufacturing is that the quantity of units kept in despatch can be reduced as the line now produces according to customers' requirements.

The implementation of these changes required assistance by Maintenance. According to Jevon (2006), an estimated total of R8 000, as shown in **Table 6-4**, was spent from 2004 to 2006 to implement changes.

Table 6-4: Total Labour Cost for Changing Over the Assembly Lines

ITEM	2004		2005		DIFFERENCE (2004-2005)	NEW - 2006		DIFFERENCE (2005-2006)
	Amount	Total (A)	Amount	Total (B)	(A-B)	Amount	Total (C)	(B - C)
Labour required to change line	0	0	14 hours	R 3,000	- R3 000	20 hours	R5 000	- R5 000
					(1)			(2)

TOTAL ONCOST (2004 to 2006) = (1) + (2)
-R8 000

Source: Self-Generated, 2006

Note:

- Labour charge out rate based on communication with Maintenance Manager as the actual income could not be disclosed to the researcher;
- Rand value for 2004/ 2005 and New –2006 are taken from Table 4-2 and Table 4-5, respectively, of Chapter Four.

The loss of this money spent needs to be looked at holistically so that an accurate picture can be attained. The net benefit of lean manufacturing and the corresponding cost in Table 6-4 is discussed in Section 6.6.

No monetary value has been allocated for training prior to the implementation of lean manufacturing as most of the training had been done on site with assistance from the customer i.e. Toyota. Toyota has actively participated in the implementation as a result of their supplier development programme (Pillay, 2006). This active participation by Toyota as the subject-matter expert further supports the data attained from the respondents discussed in Chapter Five, Section 5.3

6.6 CUMALATIVE EFFECT OF LEAN MANUFACTURING IMPLEMENTATION

The implementation of lean manufacturing on the 558N HVAC line in Smiths Manufacturing from 2005 to 2006 led to changes on raw material, labour, finished goods and implementation costs as discussed in sections 6.1 to 6.5. The net effect on the company's variable operating expenses is as shown in **Table 6-5**.

Table 6-5: Net Effect of Changes (2005 to 2006)

NET EFFECT OF CHANGES (2005 to 2006)	
Variable Operating Expense	**Amount**
Labour	R 170,277.12
Raw Material	R 215,626.60
Finished Goods (Labour Saving)	R 1,266.16
Implementation	-R 8,000.00
NET EFFECT	R 379,169.88

Source: Self-Generated, 2006

The saving from 2005 to 2006 on the 558N HVAC line is R379 169.88. The introduction of lean manufacturing on this line resulted in increasing the EBIT over this period by this amount. This saving will increase once the company adjusts its raw material stock holding policy. Further manipulation to calculations in section 6.4 after the removal of labour cost show that a "huge" saving is possible after implementation.

Implementation on other lines will, therefore, aid the company in adding more money to the bottom line and assist in attaining new business.

6.7 CONCLUDING REMARKS

Chapter Six focused on the impact of lean manufacturing implementation on variable operating expenses, viz., raw material, labour, finished goods and implementation costs. The effect of these changes on the EBIT of the 558N HVAC line was combined over a two-year period, i.e. 2005 to 2006, so that the benefit or loss of the lean manufacturing implementation could be seen.

The following chapter, viz., Chapter Seven, will discuss the conclusions and recommendations.

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

Chapter seven provides the conclusions regarding the research problem and the hypotheses. Recommendations will be made for those areas where shortfalls have been identified and further proposals for research will be suggested.

7.2 STATEMENT OF RESEARCH PROBLEM

The aim of this research is to analyze the introduction of lean manufacturing in Smiths Manufacturing. The research comprised of three sub-objectives, namely:

- To analyze the manner in which lean manufacturing was introduced on one of the assembly lines in Smiths Manufacturing;
- To analyze the financial benefit of lean manufacturing on this assembly line; and
- To analyze the benefit of lean manufacturing introduction to Smiths Manufacturing's competitive position and future existence.

7.3 RESEARCH PROPOSITIONS

The research propositions based on the three sub-objectives are:

- Smiths Manufacturing has not conformed to the recommended steps in implementing lean manufacturing;

- There has been an increase in profits due to the reduction in stock holding of sub-assemblies and finished goods; and
- The introduction of lean manufacturing has increased the competitiveness of the company.

7.4 SUMMARY OF FINDINGS

7.4.1 PROPOSITION ONE

Smiths Manufacturing have conformed to eight of the 13 steps, as emphasised by Liker, when implementing lean manufacturing. Two areas of non-conformance have been identified with insufficient information present to comment on three of the 13 steps. Based on the analysis, there is 61.5 percent conformance to Liker's implementation procedure.

7.4.2 PROPOSITION TWO

There has been a substantial amount of savings by the introduction of lean manufacturing. Quantitative analysis of the data shows a saving of R379 169.88 on the 558N HVAC line from 2005 to 2006. While the extent of savings may vary, the presence of a financial benefit after the implementation of lean manufacturing is similar to the companies discussed in Chapter Two, Section 2.3.3. This saving shows that Smiths Manufacturing has benefited from the implementation of lean manufacturing as experienced by other companies who have introduced this system.

7.4.3 PROPOSITION THREE

Improvements in the manufacturing process with regards to labour, raw materials and finished goods have improved the financial standing of the company. These improvements have led to Smiths Manufacturing being more competitive in pricing as these savings will aid in price reductions to customers as the company will be able to produce parts in a shorter lead time, more efficiently and with a minimum amount of capital being utilised in finished goods. Benefits with reduced production lead times and efficiencies are similar to research conducted by Zimmer (2000:1), Continental Design Engineering (2003:1) and NIST Manufacturing Extension Partnership (Kilpatrick 2003:3).

7.5 RECOMMENDATIONS

In order to improve lean manufacturing role out on other lines, it is recommended that Smiths Manufacturing make the following changes:

- People need to be advised of the role out plan. Knowledge of the role out plan will help, as many employees highlighted a lack of training as a major problem. The absence of training is a requirement of Liker's (2004:302) 13-step implementation procedure where employees learn by doing. If employees understand this philosophy, they will understand the reason for reduced levels of employee training;
- Management need to compile a financial analysis of the effect of lean manufacturing implementation on the bottom line. A financial analysis will help remove the subjectivity of the benefit of the system and will aid

in further increasing employee buy-in. Benefit will then be based on fact as opposed to perception; and

- Smiths Manufacturing need to take ownership of the lean manufacturing system by changing its name from TPS to a name synonymous with Smiths Manufacturing.

7.6 PROPOSALS FOR FUTURE RESEARCH

Based on the research findings, the following areas for future research are recommended:

- Identifying and researching the impact of using other lean manufacturing implementation methods on company performance;
- Exploring and comparing the effectiveness of lean manufacturing in varying industries e.g. automotive and textile industry; and
- The above research should be re-conducted using only either a qualitative approach or a quantitative approach and conclusions compared.

7.7 CONCLUDING REMARKS

In summary, this research has identified that communication involving lean manufacturing is vital to introducing a system into a company. Communication enables people at all levels to understand the roll-out procedure and the corresponding actions of the company.

This research has proved that the implementation of lean manufacturing improves manufacturing processes, which result in financial gain to the company. This improvement in the assembly processes helps reduce costs associated with manufacture of the part that aids the company in competing. Being competitive is vital to the future existence of companies competing in a global arena.

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APPENDICES

APPENDIX A: PAY RATES OF INDIVIDUALS - 2007

POSITION	RATE
Supervisor	R31.00
Line Feeder	R25.79
Packer	R23.35
Quality Controller	R25.65
Operator	R23.35

APPENDIX B: LABOUR, MATERIAL AND OVERHEAD COSTS PER 558N HVAC VARIANT

2100 – 350-01

2nd Item Number	Imported Material	Local Material	Labour Cost	Overheads	Landed Costs	Total
2100-350-01			14.0953	99.2510		
2100-350-01X	759.2935	227.4873	41.0213	146.7806	80.3219	1,254.9046
Totals:	759.2935	227.4873	55.1166	246.0316	80.3219	1,368.2509

2100-351-01

2nd Item Number	Imported Material	Local Material	Labour Cost	Overheads	Landed Costs	Total
2100-351-01			14.0953	99.2510		
2100-351-01X	568.8240	225.9158	41.0213	146.7806	73.5944	1,056.1361
Totals:	568.8240	225.9158	55.1166	246.0316	73.5944	1,169.4824

2100-352-01

2nd Item Number	Imported Material	Local Material	Labour Cost	Overheads	Landed Costs	Total
2100-352-01			14.0953	98.9711		
2100-352-01X	200.3085	201.7720	31.5112	129.4832	13.2048	576.2797
Totals:	200.3085	201.7720	45.6065	228.4543	13.2048	689.3461

APPENDIX C: PERSONAL INTERVIEW QUESTIONS AND RESPONSES

Interview Questions

The purpose of the questions is to test the interviewee's knowledge of lean manufacturing and to attain information about the implementation process. 39 Questions exist of which 17 test knowledge and 22 test the implementation procedure. Knowledge about the implementation process will be used to establish if it has conformed to either Liker's 13 step implementation procedure (2004:302), McGivern's and Stiber's (Undated:2) time frame implementation procedure or Shingo's (1990:224) one year implementation procedure. After identifying the relevant procedure, a comparison will be done between actual and theory. This will be discussed in Chapter five.

A key has been developed so that the researcher would be able to distinguish between the different responses. This differentiation was deemed necessary since some of the respondents are operators, engineers and managers. Knowledge of the response from the various employees will help in the analysis as some information will be more readily available to managers as opposed to the operators.

Key:

Line Feeder:

L1 = Line Feeder	**L2 = Line Feeder**
O = Operator	**S = Supervisor**
Q = Quality Engineer	**R = Quality Manager**
I = Industrial Trainee	**C = Industrial Engineer**
V = TIE	**W = Process Engineer**

Lean Implementation Procedure

1. What is globalization and how does it affect Smiths Manufacturing?

   (Question tests respondent's knowledge)

Variable	Category	Code	Preferred Response	Response	Qty
Suppliers	Local Sourcing	1SupplierL			
	International sourcing	1SupplierI	Preferred Response and	R	1
Competition	Excessive	1CompetitionE	Preferred Response	L2, R	2
	Minimum	1CompetitionM			
Definition	Unknown	1DefinUnknwn		L1, O	2

(? /2)

According to Hill (2003:7), globalization of production refers to the sourcing of goods from around the world in order to allow the buyer to benefit from cost and quality.

2.1 What is your definition of lean manufacturing? (Question tests respondent's knowledge)

Variable	Category	Code	Preferred Response	Response	Qty
Manu-facturing System	Quality	2.1ManSystQ	Preferred Response and	W	1
	Cost	2.1ManSystC	Preferred Response and	R	1
	Waste	2.1ManSystW	Preferred Response and	C, W, R	3
	Stock	2.1ManSystS	Preferred Response	L2, S, Q, I, V, W	6
Definition	Unknown	2.1Defin-Unknwn		L1, O	2

(? /4)

Lean Manufacturing is the process of eliminating waste or non-value added tasks in a manufacturing process through continuous improvement (McGivern and Stiber, Undated:1).

2.2 What is your definition of TPS? (Question tests respondent's knowledge)

Variable	Category	Code	Preferred Response	Response	Qty
Definition	Known	2.2DefinKnwn	Preferred Response	Q, I	2
	Unknown	2.2DefinUnknwn		L1, L2, S, O	4

(? /1)

TPS is Toyota's term for lean manufacturing (Nicholas, 1998:13).

3. What are the possible reasons for a company introducing lean manufacturing? (Question tests respondent's knowledge)

Variable	**Category**	**Code**	**Preferred Response**	**Response**	**Qty**
Pressure	Market trends	3Pressure-MarketTrend	Preferred Response or		
	Customer intervention	3Pressure-CustInterven	Preferred Response or	L1, S, Q	3
	Improvement	3Pressure-Improv	Preferred Response or	L2, O, C	3
Definition	Unknown	3DefinUnknwn	Preferred Response		

(? /1)

Today, lean manufacturing has become the buzz-word for cost reduction in a manufacturing environment. It is the buzz-word because if all companies produce a functional product, then manufacturers will have to compete on cost, service and quality (Goddard, 1986:6). In order to aid Smiths Manufacturing in competing globally, Toyota, being its customer, has aided in improving its systems i.e. supplier development.

4. What are the systems that make up lean manufacturing and how do they work? (Question tests respondent's knowledge)

Variable	**Category**	**Code**	**Preferred Response**	**Response**	**Qty**
Systems	Kanban	4SystemKan	Preferred Response and	L1, Q, O, I, V, W, R	7
	Jit	4SystemJit	Preferred Response and	L1, I, W, R	4
	Heijunka	4SystemHeij	Preferred Response and	I, R	2
	Jidoka	4SystemJid	Preferred Response and	W, R	2
	Standardised Work	4System-StandWork	Preferred Response and	R	1
	Kaizen	4SystemKaiz	Preferred Response and	V	1
System Operation	Cost/ Waste Reduction	4SystemOp-CostWaste	Preferred Response and		
	Quality Improvement	4SystemOp-QaulImprov	Preferred Response and		
	Process Improvement	4SystemOp-ProcesImpro	Preferred Response		
Definition	Unknown	4DefinUnknwn		L2, S, O, C	4

(? /9)

Systems (variable): the components that make up lean manufacturing i.e. Kanban, JIT, Heijunka, Jidoka, standardised work and kaizen are as per the TPS house (Gemba Research, Undated:2).

System Operation (variable): lean manufacturing is a systematic way of identifying and removing waste in a process. Waste is regarded as all those aspects that don't add value to the assembly process e.g. unnecessary walking. Wastage is reduced in these areas through a process of continuous improvement (Lean Manufacturing, 2005:1).

5.1 Please define (Question tests respondent's knowledge):

a) Just in time

Variable	Category	Code	Preferred Response	Response	Qty
Stock	As required	5.1aStocAs-Req	Preferred Response	L1, L2, S, Q, O, I, C, V, W, R	10
Definition	Unknown	5.1aDefin-Unknwn			

(? /1)

This is a repetitive manufacturing system in which the production and movement of parts occur just as they are required in small batches (Stevenson, 1999: 658).

b) Kanban

Variable	Category	Code	Preferred Response	Response	Qty
Stock	Visual management	5.1bStockVisMan	Preferred Response or	L1, L2, S, Q, O, I, C, V, R	9
	Supports Jit	5.1bStockSupJit	Preferred Response	W	1
Definition	Unknown	5.1bDefinUnknwn			

(? /1)

In order for the JIT system to work, suppliers need to send small amounts of stock to the customer. This stock arrives at the customer in small wheeled containers known as kanbans. According to Goddard (1986:11), kanban is the Japanese word for sign or visible record.

c) Heijunka

Variable	Category	Code	Preferred Response	Response	Qty
Production	Smoothing/Level/ Plan	5.1cProdSmooth/Plan	Preferred Response	S, I, C, V, W, R	6
Definition	Unknown	5.1cDefin-Unknwn		L1, L2, Q, O	4

(? /1)

It is a method of smoothing the production schedule thus ensuring that the customers' JIT requirements are met (Kitano, 1997:4).

d) Standardised Work

Variable	Category	Code	Preferred Response	Response	Qty
Work	Repetitive	5.1dWorkRep	Preferred Response	L2, S, Q, I, C, V, W, R	8
Definition	Unknown	5.1dDefin-Unknwn		L1, O	2

(? /1)

It is a documented standard for performing tasks that focuses on both man and machine (http://www.advancedmanufacturing.com/ lean manufacturing).

e) Continuous improvement

Variable	Category	Code	Preferred Response	Response	Qty
Change	Ongoing	5.1eChange-Ongo	Preferred Response	L1, L2, Q, O, I, C, V, W, R	9
Definition	Unknown	5.1eDefin-Unknwn			

(? /1)

It is a continuous improvement process throughout the manufacturing procedure as per customer needs (http://www.personal.psu.edu/faculty/ c/h/chc4/course/tqm/t3a.htm)

f) Jidoka,

Variable	Category	Code	Preferred Response	Response	Qty
Quality	Poke Yoke/ Elimination	5.1fQuality-PokeYok	**Preferred Answer**	R	1
Definition	Unknown	5.1fDefin-Unknwn		L1, L2, S, Q, O, I, C, V, W	9

(? /1)

It has two separate meanings i.e. automation and autonomation. Automation refers to changing the process from a manual process to an automated process. The problem with this is that the process has no way of detecting errors hence, the need for autonomation. Autonomation is an automated process with the ability to detect and correct errors hence, reducing scrap (http://www.personal.psu.edu/faculty/c/h/chc4/course/tqm/t3a.htm)

g) ANDON system

Variable	Category	Code	Preferred Response	Response	Qty
Manage-ment	System	5.1gManage-System	Preferred Response	L1, S, Q, O, C, V, W, R	8
Definition	Unknown	5.1gDefin-Unknwn		L2, I	2

(? /1)

According Shingo (1990:74), an andon system is a visual control that communicates important information via a visual signal i.e. a light. This signal, which has a specific meaning, aids in managing the line.

TOTAL = (? /7)

5.2 What are the differences between TPS and lean manufacturing? (Question tests respondent's knowledge)

Variable	Category	Code	Preferred Response	Response	Qty
Definition	Known	5.2aSystem-Same	Preferred Response	L2, S, V	3
	Unknown	5.2aSystems-Different		W, R	2

(? /1)

Other common names for lean manufacturing include World Class Manufacturing, Stockless Production, Continuous Flow Manufacturing, Just in Time Manufacturing and TPS (Toyota Production Systems) (Strategos Consultants, Engineers and Partners, Undated:2). TPS and lean manufacturing are thus the same.

6. Has lean manufacturing been introduced in Smiths Manufacturing? (Question tests respondent's knowledge)

Variable	Category	Code	Preferred Response	Response	Qty
Introduction	Yes	6IntroYes	Preferred Response	L1, L2, S, Q, O, I, V, W, R	9
	No	6IntroNo			
	Unknown	6IntroUnknwn			

(? /1)

The preferred response is based on knowledge by the interviewer since he works in the company.

7. When did this occur? (Question relevant to implementation process)

Variable	Category	Code	Preferred Response	Response	Qty
Time	< 1 year	7Time<1	Supports Shingo, McGivern and Stiber and Liker	L2, S, O	3
	2 to 3 years	7Time2to3	Supports Shingo, McGivern and Stiber and Liker	V, R	2
	3 to 5 years	7Time3to5	Supports Shingo, Mcgivern and Stiber	L1, Q	2
	> 5 years	7Time>5	Supports Shingo and Liker	W	1
	Unknown	7TimeUnknwn	Preferred Answer	I, C	2

(? /1)

According to Liker (2004:302), a company needs to undergo 13 steps to become a lean enterprise. A time frame is not mentioned hence, all categories are relevant. McGivern and Stiber (Undated:2) however, state that lean manufacturing implementation should take five years hence, all categories equal to five years or less are relevant. Shingo believes that the time frame will vary depending on the capacity of the manufacturing plant (1990:224) hence, all time frames are relevant.

8. What has been the procedure for lean manufacturing implementation in Smiths Manufacturing? (Question relevant to implementation process)

Variable	Category	Code	Preferred Response	Response	Qty
Implemen-tation	Training Operators	8Implement-TrainOper	Supports Shingo and Mcgivern and Stiber		
	Training office staff	8Implement-TrainOff	Supports Shingo, Mcgivern and Stiber and Liker	I, V, W	3
	Single line	8Implement-Single	Liker		
	Multiple lines	8ImplementMul			
	Waste Identification	8Implement-WasteId	Supports Shingo, Mcgivern and Stiber and Liker	W	1
	Customer	8Implement-Cust		L1, W	2
	Management	8ManDriven	Liker	S, R	2
	Unknown	8Implemen-tationUnknwn		O, C	2

With regards to training, Shingo (1990:223) and Mcgivern and Stiber (Undated:3) suggest training first and then implementing lean manufacturing while Liker (2004:302) suggests that training should occur after the implementation process. Liker has been considered as the preferred response with regards to training the office staff as they (management) will be responsible for the implementation and need to know the implementation process.

Implementation on one line first supports Liker's 13 step procedure (2004:302). Shingo and Mcgivern and Stiber don't specify quantity of lines to be used as initial lean manufacturing implementation hence, they have not been considered.

All three methods improve processes through waste identification and removal.

9. How have areas of waste been identified? (Question relevant to implementation process)

Variable	Category	Code	Preferred Response	Response	Qty
Identification	Material flow chart	9IdentiMater-Flw	Liker		
	Visual	9IdentiVisual	Liker	L1, L2, S, I, C, W, R	7
	Unknown	9IdentiUnknwn		Q, O, V	3

(? /1)

Liker (2004:302) advises plotting material and information flow diagrams of actual occurrences. Plotting the path of a part from start to finish helps the team collectively see and identify areas of waste.

10. What is a material flow chart? (Question tests respondent's knowledge)

Variable	Category	Code	Preferred Response	Response	Qty
Chart type	Process Schematic	10ChartTyp-Process		R	1
	Material Schematic	10ChartTypMat	Preferred Answer	S, Q, C, W	4
	Unknown	10ChartType-Unknwn		L1, L2, O, I	4

(? /1)

It is a pictorial representation of a process being studied (http://deming.eng.clamson.edu/pub/tutorials/qctools/flowm.htm)

11.1 What is your opinion of the lean manufacturing implementation with regards to employee training? (Company involvement, funds spent, levels trained – engineers/managers/operators, time trained for). (Question relevant to implementation process)

Variable	Category	Code	Preferred Response	Response	Qty
a) Company involvement	Proactive	11.1aComp-InvolvProac	Supports Shingo and Mcgivern and Stiber	C	1
	Reactive	11.1aComp-InvolvReac			
	Unknown	11.1aComp-InvolvUnknwn			
b) Funds Spent	Excessive	11.1bFunds-SpentExces		L1	1
	Minimum	11.1bFunds-SpentMin		L2, V, R	3
	Unknown	11.1bFunds-SpentUnknwn		S	1
c) Training	Operators only	11.1cTrainOp			
	Office staff only	11.1cTrainOff			
	All staff	11.1cTrainAll	Supports Shingo, Mcgivern and Stiber		
	Excessive	11.1cTrain-Excess			
	Insufficient	11.1cTrain-Insuff		L2, S, Q, I, C, V, R	7

	Unknown	11.1cTrain-Unknwn			

(? /3)

With regards to training, Shingo (1990:223) and Mcgivern and Stiber (Undated:3) suggest training everyone first hence, a proactive approach.

11.2 With regards to the TPS implementation in Smiths Manufacturing, have you gone for training on TPS? (Question relevant to implementation process)

Variable	**Category**	**Code**	**Preferred Response**	**Response**	**Qty**
a) Training	Had	11.2aTrainYes	Supports Shingo, Mcgivern and Stiber	S, I, V	3
	Had Not	11.2aTrainNo	Supports Liker	L1, L2, O, C, R	5

(? /1)

With regards to training, Shingo (1990:223) and Mcgivern and Stiber (Undated:3) suggest training first and then implementing lean manufacturing while Liker (2004:302) suggests that training should occur after the implementation process.

12. With regards to training – Have the people been involved in lean implementation and then been trained later or have they been trained first and then involved in lean manufacturing implementation? (Question relevant to implementation process)

Variable	Category	Code	Preferred Response	Response	Qty
Training	Pre lean introduction	12TrainPreLean	Supports Shingo, Mcgivern and Stiber	L2, C, W	3
	Post lean introduction	12TrainPost	Supports Liker	S, Q, C, V, R	5
	During lean introduction	12TrainDuring	Supports Liker	I, C, W	3
	Unknown	12TrainUnknwn			

Learn by doing first and training second. According to Liker (2004:302), the ratio of doing to learning is 80 percent doing to 20 percent learning hence, training during or post is the preferred response for Liker. Pre - training supports Shingo (1990:223) and Mcgivern and Stiber (Undated:3).

13. What is your perception of the levels of understanding of lean manufacturing for operators? (Question relevant to implementation process)

Variable	Category	Code	Preferred Response	Response	Qty
Understand-ing	Good	13Understnd-ngGoodOp	Supports Shingo, Mcgivern and Stiber	I	1
	Okay	13UnderstndngOKOp		L1, L2, S	3
	Bad	13UnderstndngBadOp		O, V, W	3
	Unknown	13UnderstndngUnknwnOp			

Response is dependent on respondent perception. The "Good" category supports Shingo (1990:223) and Mcgivern and Stiber (Undated:3) as they encourage understanding of the system prior to implementation.

14. What is your perception of the levels of understanding of lean manufacturing for managers? (Question relevant to implementation process)

Variable	Category	Code	Preferred Response	Response	Qty
Understanding	Good	14Understnd-ngGoodMan	Supports Shingo, Mcgivern and Stiber and Liker	L2, Q, W	3
	Okay	14Understnd-ngOKMan		C	1
	Bad	14Understnd-ngBadMan		I, V	2
	Unknown	14Understand-ngUnknwnMan			

Response is dependent on respondent perception. The "Good" category supports Shingo (1990:223) and Mcgivern and Stiber (Undated:3) as they encourage understanding of the system prior to implementation.

15. What is your perception of the levels of understanding of lean manufacturing for engineers? (Question relevant to implementation process)

Variable	Category	Code	Preferred Response	Response	Qty
Understand-ing	Good	15Understand-ingGoodEng	Supports Shingo, Mcgivern and Stiber and Liker	L1, L2, Q	3
	Okay	15Understand-ingOKEng		C, W	2
	Bad	15Understand-ingBadEng		V	1
	Unknown	15Understand-ingUnknwnEng		O	1

Response is dependent on respondent perception. The "Good" category supports Shingo (1990:223) and Mcgivern and Stiber (Undated:3) as they encourage understanding of the system prior to implementation.

16. Who in the organisation is the driver of lean manufacturing implementation i.e. is it driven top down or bottom up. Elaborate? (Question relevant to implementation process)

Variable	Category	Code	Preferred Response	Response	Qty
Driver	Management (Top down)	16DriverMan	Supports Shingo and Liker	L2, Q, I, C, W, R	6
	Engineering (Top down)	16DriverEng	Supports Shingo and Liker	L2, S, Q, O, I, C, V, W, R	9
	Production (Top down)	16DriverProd	Supports Shingo and Liker	L1	1
	Operators (Bottom Up)	16DriverOp	Supports Mcgivern and Stiber - kaizen	L2	1
	Unknown	16Driver-Unknwn			

(? /1)

All three implementation procedures will have management being the initial driver as they are responsible for the running of the company. McGivern and Stiber are the only people who mention that kaizen must be driven bottom-up (Undated:3).

17. Has lean manufacturing been initially introduced on all lines or have specific lines been chosen? (Question relevant to implementation process)

Variable	**Category**	**Code**	**Preferred Response**	**Response**	**Qty**
Role out	Single line	17RoleOut-Single	Supports Liker	L1, L2, S, Q, I, C, V, R	8
	Multiple lines	17RoleOutMul	Supports Shingo, Mcgivern and Stiber	W	1
	Unknown	17RoleOut-Unknwn		O	1

(? /1)

Implement lean on one line first so that employees can see the benefits of the system (Liker, 2004: 302). This is different to Mcgivern and Stiber (Undated:3) who suggest implementing lean manufacturing in the entire organisation. Shingo does not make reference to introduction on a specific line hence, the researcher has regarded it as multiple lines.

18. Are process improvements in Smiths encouraged from employees at all levels? How – elaborate? (Question relevant to implementation process)

Variable	Category	Code	Preferred Response	Response	Qty
a)Encour-aged	Yes	18aEncourag-edY	Supports Shingo, Mcgivern and Stiber and Liker	L2, S, O, I, C	5
	No	18aEncourag-edN		Q, W, R	3
	Unknown	18aEncourag-edUnknwn		V	1
b)Encour-agement procedure	Incentives	18bEncourage-ProcedIncent	Supports Shingo, Mcgivern and Stiber and Liker	L1, L2, S, I, C, R	6
	Recognition	18bEncourage-ProcedRecog	Supports Shingo, Mcgivern and Stiber and Liker		
	None	18bEncourage-None		W	1
	Unknown	18bEncourageP roced-Unknwn		O	1

(? /2)

Liker (2004:302), Mcgivern and Stiber (Undated:3) and Shingo (1990:223) all encourage employee participation in suggesting improvements. This is done through creating the necessary culture that encourages such behaviour.

19. Do you think that lean manufacturing is restricted to a certain industry? If yes, why, if no, why? (Question tests respondent's knowledge)

Variable	Category	Code	Preferred Response	Response	Qty
Applicability	Yes	19ApplicabilityYes		L1, S, I	3
	No	19ApplicabilityNo	Preferred Response	L2, Q, C, V, W, R	6
	Unknown	19ApplicabilityUnknwn		O	1

(? /1)

Lean manufacturing is a systematic way of identifying and removing waste in a process. Following the path of a part from start to finish identifies areas of waste. Wastage is reduced in these areas through a process of continuous improvement (Lean Manufacturing, 2005:1). According to the definition, there is no restriction on the industry. Hence, the preferred response is "No".

20. What is your opinion of batch building? Do we need it and why?

(Question tests respondent's knowledge)

Variable	Category	Code	Preferred Response	Response	Qty
a) Batch building	Good	20aBatchBuild-Good		I	
	Bad	20aBatchBuild-Bad	Preferred Response	L1, L2, S, Q, O, R	6
	Unknown	20aBatchBuild-Unknwn			
b) Outcome	Cost	20bOutcome-Cost	Preferred Response	L2, Q, O, R	4
	Unknown	20bOutcome-Unknwn			

(? /2)

The opposite of batch production is JIT production. According to Shingo (1989:69), JIT is the procedure where each process is supplied with the required parts in the required quantity and time when needed hence, the terminology. The purpose of JIT is to reduce stock holding to eliminate unnecessary funds to be present in unutilized goods. These funds, which occur as a result of excess stock, would be present if batch building is present.

21. Have lean principles been introduced throughout the supply chain? (Question relevant to implementation process)

Variable	Category	Code	Preferred Response	Response	Qty
Supply Chain Introduction	Yes	21SupChain-IntroYes	Supports Shingo, Mcgivern and Stiber and Liker	L1, S, Q, I, C, V, W, R	8
	No	21SupChain-IntroNo			
	Unknown	21SupChain-IntroUnknwn		L2, O	2

(? /1)

This is a requirement after lean manufacturing has been introduced in the organisation. All three authors i.e. Liker (2004:302), Mcgivern and Stiber (Undated:3) and Shingo (1990:223) support the introduction of lean manufacturing throughout the supply chain.

22. Is standardised work present when assembling a product? (Question tests respondent's knowledge)

Variable	Category	Code	Preferred Response	Response	Qty
Standardised Work	Yes	22StdWorkYes	Preferred Response	L1, O, I, C	4
	No	22StdWorkNo			
	Unknown	22StdWork-Unknwn		V	1

(? /1)

The preferred response is based on the TPS house where standardised work forms part of the diagram (Gemba Research, Undated:2).

23. How has the implementation of lean manufacturing affected your working conditions? (Question relevant to implementation process)

Variable	Category	Code	Preferred Response	Response	Qty
a) Working Conditions	Good	23aWorkCond-Good	Supports Shingo, Mcgivern and Stiber and Liker	L2, S, O, C	4
	Bad	23aWorkCond-Bad		L1, S, O	3
	Unchanged	23aWorkCond-Unchanged		Q	1
	Unknown	23aWorkCond-Unknwn		I	1
b) Job Security	Improved	23bJobSec-Improved		V	1
	Reduced	23bJobSecRed			
	Unchanged	23bJobSec-Unchanged		S, C, R	3
c) Work Load	Increased	23cWorkLoad-Increase		W, R	2
	Reduced	23cWorkLoad-Red		L2, C	2
	Unchanged	23cWorkLoad-Un			

Lean manufacturing favours one to one production. Hence, there is reduced work in progress (Epply and Nagengast, Undated:2). Lean manufacturing attacks the wasteful areas of the process which reduces costs, improves quality and services the needs of the customer quicker. All three authors i.e. Liker, Shingo and McGivern and Stiber encourage lean manufacturing implementation because of its benefits hence, the category of "Good" was chosen for working conditions as the operator would now work more efficiently.

No preferred response exists for job security and work load as this will be dependent on the situation. No job loss is evident in Smiths Assembly.

24. Has this change impacted on your willingness to change your style of working so that it encompasses lean principles? (Question relevant to implementation process)

Variable	**Category**	**Code**	**Preferred Response**	**Response**	**Qty**
Willingness	Increased	24Willingness-Increased		C	1
	Reduced	24Willingness-Red			
	Unchanged	24Willingness-Un		L	1

The response is dependant on respondent opinion.

25. What is your opinion on the principle of lean manufacturing? Should we continue to introduce it or not? (Question relevant to implementation process)

Variable	Category	Code	Preferred Response	Response	Qty
Lean Opinion	Good	25LeanOpinion Good	Supports Shingo, Mcgivern and Stiber and Liker	L1, L2, S, Q, O, I, C, W, R	9
	Bad	25LeanOpinion Bad		L1	1
	Unknown	25LeanOpinion Unknwn			

Lean manufacturing favours one to one production hence, reduced work in progress (Epply and Nagengast, Undated:2). Lean manufacturing attacks the wasteful areas of the process which reduces costs, improves quality and services the needs of the customer quicker. All three authors i.e. Liker, Shingo and McGivern and Stiber encourage lean manufacturing implementation because of its benefits. Hence, the category of "Good" was chosen.

Financial Benefit

1. Why is there a need to reduce costs through implementing new manufacturing systems? (Question tests respondent's knowledge)

Variable	Category	Code	Preferred Response	Response	Qty
Cost Reduction	Competition	1CostReducComp	Preferred Response or		
	Profit	1CostReducProfit	Preferred Response	L1, L2, Q	3
	Unknown	1CostReducUnknwn		O	1

(? /1)

International sourcing allows companies to take advantage of national differences in the cost and quality of the product (Hill, 2003:7). A cost reduction aids the company in supporting aggressive pricing (Hill, 2003:423). This reduction is vital in an environment where there are strong pressures to reduce costs. Cost reduction is one of the competitive pressures that global firms experience (Hill, 2003:417). Suppliers, therefore, need to ensure that their products are cheap and of desirable quality as they are no longer competing in national markets but global markets. "Competition and Profit" are, therefore, the categories for the preferred response.

2. What impact has lean manufacturing had on job security? (Question relevant to respondent's perception)

Variable	Category	Code	Preferred Response	Response	Qty
Job Security	Improved	2JobSec-Improved			
	Reduced	2JobSecRed			
	Unchanged	2JobSecUn		L1, L2, Q, O, C	5

The response is dependant on respondent opinion and occurrences in company.

3. Has lean manufacturing provided any financial gain/loss to the company? Elaborate. (Question relevant to respondent knowledge)

Variable	Category	Code	Preferred Response	Response	Qty
Financial Effect	Improved	3FinEffect-Improved	Preferred response	L2, S, Q, C, W, R	6
	Reduced	3FinEffectRed			
	Unchanged	3FinEffect-Unchange			
	Unknown	3FinEffect-Unknwn		L1, I	2

Research conducted by Zimmer (2000:1) revealed that companies implementing lean manufacturing have achieved improvements in excess of ten percent increase in direct labour utilization, 50 percent increase in indirect labour use, 50 percent reduction in inventory, 70 percent decrease in manufacturing cycle time and 50 percent increase in capacity on current machines. While this is so, respondent response will be dependent on exposure to such information.

4. Is the financial gain/loss of lean manufacturing documented? If so, is it freely available? (Question relevant to implementation process and respondent knowledge)

Variable	**Category**	**Code**	**Preferred Response**	**Response**	**Qty**
a) Financial Effect	Documented	4aFinEffectDoc	Emphasised by Liker		
	Not Documented	4aFinEffectNotDoc		C, V	2
	Unknown	4aFinEffectUnknwn		Q, O, W, R	4
b) Financial Access	Available	4bFinAccAvail	Emphasised by Liker		
	Unavailable	4FinAccUnavail		L2, S	2
	Unknown	4FinAccUnknwn			

(?/2)

According to Liker (2004:302), choosing lines that can show a financial benefit after lean manufacturing implementation will assist in attaining buy in from other members in the organization.

5. In your opinion, what has the absence of a cost-benefit analysis of lean manufacturing done to the implementation process in the remainder of the company? (Question relevant to implementation process and tests respondent perception)

Variable	Category	Code	Preferred Response	Response	Qty
Absence of financial disclosure	Helped	5AbsFinHelp-ed	Emphasised by Liker		
	Hindered	5AbsFinHinder		S, C, V, R	4
	Unknown	5AbsFin-Unknwn			

The response is dependent on respondent opinion and on exposure to such information.

6. Would you rate the implementation of lean manufacturing systems such as live racking and smaller bins as being an on cost or a cost reduction? (Question tests respondent perception)

Variable	Category	Code	Preferred Response	Response	Qty
Lean Implemen-tation	On cost	6LeanImpleOn Cost		I	1
	Cost Reduction	6LeanImple-CostRed		L2, S, Q, C, R	5
	Unknown	6LeanImple-Unknwn			

The response is dependent on respondent opinion and on exposure to such information.

Effect on Strategy and Competitiveness

1. What is your definition of business strategy? (Question tests respondent's knowledge)

Variable	Category	Code	Preferred Response	Response	Qty
Strategy	Way forward	1StratWayForwrd	Preferred Response	L1, L2	2
	Unknown	1StratUnknwn		O	1

(? /1)

Strategy is the direction and scope of the company for the future (Johnson and Scholes, 2002:10). Hence, the category of "Way Forward" was chosen.

2. How has lean manufacturing implementation affected the competitiveness of the company? (Question tests respondent knowledge)

Variable	Category	Code	Preferred Response	Response	Qty
Company competitive-ness	Increased	2Compny-CompetIncr	Preferred Response	L1, L2, S, Q, I, V, W, R	8
	Reduced	2Compny-CompetRed			
	Unchanged	2CompnyCompetUnchanged			
	Unknown	2CompnyCompetUnknwn			

(? /1)

The response is dependent on respondent opinion as it could be either positive or negative due to the implementation procedure.

3. What is your opinion on how the company sees kaizen? (Projects implemented, incentives) (Question tests respondents perception)

Variable	Category	Code	Preferred Response	Response	Qty
Kaizen	Good	3KaizenGood		L1, S, O, C, V	5
	Bad	3KaizenBad			
	Unknown	3Kaizen-Unknwn			

(? /1)

Response dependent on experiences in the company.

4. Do you think that sufficient time, effort and funds are allocated for manufacturing improvements and systems? (Question relevant to implementation process)

Variable	**Category**	**Code**	**Preferred Response**	**Response**	**Qty**
Resource Allocation	Sufficient	4ResourceAll-Suff		L1, L2, I	3
	Insufficient	4ResourceAll-Insuff		C, V	2
	Unknown	4ResourceAll-Unknwn		O	1

The response is dependent on respondent opinion and exposure and involvement in such areas.

5. General input that can help for future implementations? (Question relevant to implementation process)

Variable	**Category**	**Code**	**Preferred Response**	**Response**	**Qty**
Training	Sufficient	5TrainSuff			
	Insufficient	5TrainInsuff		L1, Q, O, C, R	5
Communi-cation	Sufficient	5TrainSuff			
	Insufficient	5TrainInsuff		L, O	2

The response is dependent on respondent opinion.

APPENDIX D-1: PERSONAL INTERVIEW CONSENT FORM – RESPONDENT ONE

Letter of Information and Consent

13 Geranium Road

Brindhaven

Verulam

4340

Dear Participant,

Letter of Information and Consent

An Evaluation of the Introduction Of Lean Manufacturing In a Selected South African Organization

I am currently conducting a research project that is a requirement for my Masters in Business Administration degree. The aim of the research is to analyze the introduction of lean manufacturing in Smiths Assembly.

Your participation in either the focus group or personal interview is greatly appreciated, as it is vital to draw conclusions about the introduction and implementation of lean manufacturing. The research together with its conclusions will identify problematic areas, which will be made known to the organization. It is at the discretion of the organization to address the problematic areas.

All information attained from interviews and focus groups will be kept confidential. If further information is needed regarding the research procedure or topic please feel free to contact my supervisor (Mrs. Melanie Lourens 031 308 6795) or myself.

Yours sincerely

V. Moorthi

031- 719 4152

I ....Ivor.......... voluntarily agree to participate in the ~~focus group~~/ interview (delete which ever is not applicable). I am aware that I can withdraw my participation at any time.

Signature .

Date ...25-09-06...........