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Analysis and reduction of waste in the work process using manufacturing kaizen tool. A case study.

by

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Dissertation

submitted in the fulfillment of the requirements for the degree

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Declaration of the candidate

I, Gift Sizwe Nhlabathi, declare that this dissertation is my own work, unaided work except to the extent indicated in the acknowledgment and references.



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ABSTRACT

Analysis and reduction of waste in the work process using manufacturing kaizen tool. A case Study.

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The research is about the application of lean manufacturing tool known as manufacturing kaizen in order to improve a work process at APSAP PTY LTD. The company is based in Kempton Park, South Africa, used as a case study to evaluate the benefit of manufacturing kaizen at a specific industrial concern. The research demonstrated how manufacturing kaizen when used appropriately can help APSAP PTY LTD to eliminate waste, have better inventory control, short process cycle times, and better overall financial and operational procedures.

The goal was to reduce the identified waste using manufacturing kaizen tool. Waste reduction eventually reduced the cycle time of the work process. The primary objective of the thesis was to study and analyze the cylinder preparation process in APSAP PTY LTD. The process activities were captured, then analyzed using the process map. The secondary objective was to identify waste in the process.

Major businesses in South Africa have been trying to adopt new business initiatives in order to stay competitive. One way to increase this is to apply proper manufacturing strategy and use of lean manufacturing or continuous improvement tools to achieve business objective which is to stay competitive and to increase profit. The research addresses the application of a lean manufacturing tool called manufacturing kaizen.

Manufacturing kaizen refers to a technique used for improving a work process by the eliminating waste within that process in the organization. It is one of the improvement tools that focus on cost reduction by eliminating non-value added activities. Kaizen achieves the elimination of waste by empowering people with tools and a process to uncover improvement opportunities and make change. Participants are key aspect in implementing the manufacturing kaizen event, since they are the people directly involved.

Identifying the key people that will be used in the manufacturing kaizen event is very crucial for the success of the event. Any changes or improvements of the process will have direct impact to the people. It is important that people who are directly affected by change become part of the process and feel empowered.

Kaizen understands waste to be any activity that is not value adding from the perspective of the customer. The research unpacks manufacturing Kaizen and looks into its qualitative nature and its application within a working environment and how it influence productivity. It also investigates how this tool can be applied in a process or chemical industry and the benefits it can provide to an organization.

The initial step in the approach was to outline data collected and examining techniques used to collect the data. The researcher carried out direct observation as he was physically present, and personally monitored what was taking place. The results show that labor productivity can be improved over time after the introduction of manufacturing kaizen. It concludes that with the introduction of manufacturing kaizen, transformation at workplace can be established leading to productivity improvement within an organization.

The research has shown that with the proper use of manufacturing kaizen, waste reduction can be achieved. This was proved by reduction of the scrap rate of 100%, leading to the company saving R 251 020.80 on revenue as well as increase in labour utilization of 242.28%.

Other improvements that were noted were 27% on set up times, 18% on interruption, 2% on inspection, 26% on travel/transport time, 18% on waiting time and 14% on searching time. These led to a 70% rate of improvement on cycle times .



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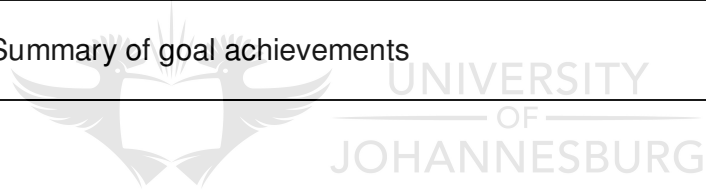
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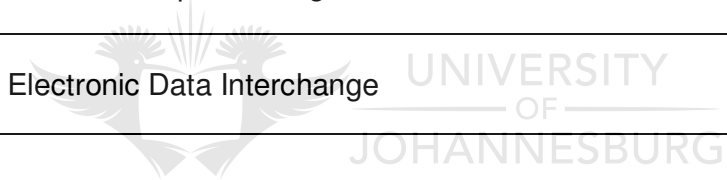
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List of acronyms

WOVC	Workplace organizational and visual controls
TPS	Toyota production system
SMED	Single minute exchange of dies
5s	Sort, straightened, sweep, systemize and standardize
JIT	Just in Time
JITD	Just in Time distribution
JITP	Just in Time purchasing
EDI	Electronic Data Interchange



CHAPTER 1

1. Introduction

1.1 Background

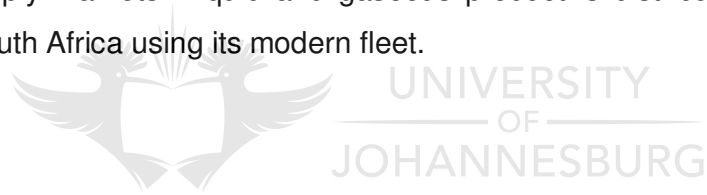
The research was about the application of lean manufacturing tool known as manufacturing kaizen to improve a work process at APSAP PTY LTD. Manufacturing kaizen (pronounced kye-zen) means improvement in Japanese and refers to a method for improving a work process by the eliminating waste in the process (Womack & Jones 1994). The ideology of Manufacturing kaizen can be traced back to the 1980's; and was first adopted in the West with the influx of Japanese car manufacturers that brought a wave of new thinking. The tool achieves the elimination of waste by empowering people with methods and a process to uncover improvement opportunities and make changes.

Manufacturing kaizen refers to waste as any activity that adds no value to final product, from the perspective of the customer. Value adding, means any work that materially changes a product or service in ways that a well-informed and reasonable customer is willing to pay for. Waste consumes resources pointlessly (Womack, Jones & Ross 1990). The resources are predominantly human and input material into the process. People that implement wasteful processes do not add value to the business. Often people are deprived of engaging in meaningful tasks that produce high quality outputs that are highly regarded by customers.

Lean practitioner in manufacturing kaizen events demonstrated that the level of value adding activity in unimproved work processes is less than 5% (Hines & Taylor 2000). Another way to view the statement is that only 5% of the material resources invested in the company leverage return to owners, the rest is wasted. The application of manufacturing kaizen reverses the consequences of wastes. Manufacturing kaizen empowers people to grow to the full measure of their capabilities. By continuously eliminating waste, people continually increase the amount of the material resources that leverage payback and not simply payout (Panizzolo 1998).

APSAP PTY LTD manufactures the majority of its products within South Africa at its 9 strategically located facilities. One of the company's main objectives has been to introduce innovative solutions to effect savings and significant production increases for the industrial gas user. The company produces products like, oxygen, nitrogen, acetylene gasses, etc. The company has achieved significant success and growth. The company offers specialized chemical products such as polymers, polyurethane and performance chemicals as well as industrial chemicals.

The company's ISO 9000 listing is a foundation upon which the process of continuous improvement makes the company a world-class gas supplier. The researcher worked for the company. The company is located in Kempton in South Africa and has a workforce of 415. The company has grown rapidly over the past 41 years in utilizing its world-class production and distribution facilities throughout Southern Africa. The company has become the largest supplier in the on-site and pipeline market. APSAP is also a leader in the bulk, cylinder, specialty gas and chemicals supply markets. Liquid and gaseous product is distributed to customers throughout South Africa using its modern fleet.



1.2 Problem statement

Major businesses in South Africa are trying to adopt new business initiatives in order to stay competitive and to meet customer demand. APSAP PTY LTD was one the companies faced with a high demand of gas cylinders from customers. APSAP PTY LTD was used as a case study. The problem was that the company was not meeting the high customer demand due to longer cycle times.

APSAP could not prepare enough empty cylinders for filling and shipping in time. For example the order intake in fiscal 2007 was up by 7% to the previous year's figure of R 1,831 million at R1, 977 million. The previous year's figure had included several large orders, as shown in Table1 below. The business in 2007 was more dominated by a large number of smaller and medium-sized orders. The order backlog remained at a high level for instance as at December 25, 2007, which amounted to R4, 772 million, compared with R4, 541 million in the previous year.

Table 1. APSAP PTY LTD indicator: (Source: Researcher, 2007)

APSAP PTY LTD indicators		
(R million)	2006	2007
Sales	2,141	2,007
Order intake	1,831	1,977
Order backlog (Dec. 25)	4,541	4,772

Manufacturing kaizen tool was used to solve the problem. The tool was applied to improve the cycle time. Non-value added activities in the cylinder preparation area were eliminated. Non value added activities are waste such as longer waiting times, unnecessary interruptions, searching times, unnecessary inspections, movements and set up times. Manufacturing kaizen can be used in junction with other lean manufacturing tool. Total Productive Maintenance (TPM), Just In Time (JIT) and Workplace Organisation and Visual Controls (5s) are discussed in the chapter 2.

Application of manufacturing kaizen to the continuous process industry has been distant. The argument has been that such industries are efficient. The need for such improvement activities was not seen. Managers have also been hesitant to adopt the lean manufacturing tools and techniques. The reasons are that the industry is characterized as a high volume and long setup times process industry. While it seems that some lean manufacturing tools are difficult to adapt in the process industry, other are not. For example, (Cook & Rogowski 1996) and (Billesbach 1994) used just-in-time concept at a process facility, and both reported good results.



1.3 Research objectives

The goal was to reduce the identified waste using manufacturing kaizen tool. Waste reduction eventually reduced the cycle time of the work process. The primary objective of the thesis was to study and analyze the cylinder preparation process in APSAP PTY LTD. The process activities were captured, then analyzed using the process map. The secondary objective was to identify waste in the process.

In the research APSAP PTY LTD was used as case study. The research was carried at an actual facility. APSAP had to make sure empty cylinders are prepared and sent to the production area in time. The company was not meeting the high customer demand. APSAP could not in time prepare enough empty cylinders for filling. Chapter 4 of the research addresses how waste reduction resolved the problem faced by APSAP.

The process begins with getting an order and then completing a pre-fill inspection of the manifold and scale. The operator makes sure the manifold lines have no leaks and the scale is properly zeroed out. The pre-fill inspection requires hooking up a cylinder so that the lines and scale can be tested. This is called a 'scale check cylinder.' Then the operator removes the scale check cylinder and loads the line with cylinders to be filled. This means placing the cylinders on the scale that sits on each side of the manifold and hooking them up to the fill lines. The process activities were captured, then analyzed using the process map.

1.4 Research methodology

The methodology outlines the approach used for data collection. The researcher conducted direct observations. Data collection was over a period of five days. Firm conclusion was made out of the data. The approach was flexible. Observation is one of a few options available for studying records (Cooper & Schindler 1998: 366). Participants were key aspects in conducting the research. The research approach helped in addressing the goal of the company. The approach also outlines the analysis of data. Waste in the work process was analyzed and eliminated. The goal was to eventual reduce waste in the cylinder preparation area.

1.4.1 Data collection

Data was collected from the correct subject matter experts who were part of the manufacturing kaizen team. The collection of information was precise, because right team members were used in the data collection process. The team was made up of different team members as specified below.

- Timekeeper Role: Reported the time it took to complete a work activity using a stop watch so that the cycle time of each work activity was known.
- Distance Measurement Role: Reported the distance an operator moved while executing a task by using a distance wheel.
- WOVC Evaluator Role: Evaluated the workplace with respect to organization, safety, and the use of visual displays, metrics and controls using the WOVC Evaluation Form, so that the current status of workplace organization and use of visual controls is understood.
- Photographer Role: Developed a visual baseline for improvement by visually documenting the current state of the workplace. A digital camera was used so that improvements could be identified and communicated to the key stakeholders.
- Spaghetti Charting Role: Illustrated the travel/movement of the operator by drawing lines to depict these movements. The work-place layout sheets and a pencil were used so that a graphical image of the amount and orderliness of operator movement, as required by the job, can be displayed.

Initially, a process map was used to plot the current state of cycle times and cylinder preparation processes. Secondly, a walk-through of the target work (problem area) was conducted in order to identify waste sources. Thirdly, a mission statement was created that clearly defined the business problem in need of improvement. Fourthly, goals were set in the form of a goal statement comprised of two components: a “what” statement which addressed the state of the waste to be reduced and a “how much” statement that described the quantity of waste that could be reduced. Finally, the “dos” and “don’ts” were defined to enable participants to maintain focus within the scope of the project.

1.4.2 Data analysis

Once data from the walk-through phase was collected, it was entered manually into microsoft word on the waste observation sheet and then fed into the flow process recap sheet, as shown in table 3 in chapter 4. Data was analyzed using the process recap sheet. Details of how the data was further analyzed are discussed in chapter 4.

1.4.3 Validity and Reliability

In order to draw appropriate conclusions from a study, it was important for the research team to demonstrate that a tool used is both reliable and valid or the entire research can be rendered meaningless (Babbie 1998). Acquiring whether the application of the tool was appropriate was important. The detail list of contents was constructed. The detail list of contents provided information needed to understand whether the application of manufacturing kaizen was appropriate to achieve the desired business results.

The detail list of content in Table 2 below was used to justify the research design in order to reach a convincing conclusion. All the required steps were completed. All the steps were achieved by completing the scope document attached as appendix D. Hence, manufacturing kaizen was a valid and reliable tool to use to solve the problem the company faced.

Table 2. Detailed List of Contents: (Source: Vitab .L, Butz .F, and Vital .P .2007)

1.Name/Description of the target Work Process:	You need to know this information so that you focus your energies on improving the right work process.
2.Who is the Manager of this Work Process	You need to know who that person is since she/he is a major stakeholder in the event and is the person you may contact for completing the Scope Document
3.Who owns the improvements to this work process?	You need to know who that person is so that you can give ownership of the results and the sustaining of them.
4. How many people and shifts are involved in this work process?	You need to know this so that you can anticipate: (a) the total hours worked per day in the Target Work Process; (b) the total hours worked per week and per shift in the Target Work Process; (c) the % the Target Work Process performed by employees; and (d) the % of the Target Work Process performed by contractor employees. You will need all this information when preparing and calculating the benefits of the event.
5. Locations where this process is performed (for scoping and replication)	You need this information to complete your understanding of the size of the business you will be working with and to help you build a sense for the labor contribution to the cost of operating the business. You also need this information to ensure the results of your event can be replicated across all sites that have the same Target Work Process.
6.How often is this process performed?	You need this information to better understand the impact of improvements for the site.
7. What is the cycle time of this process? Is it possible to Observe this process during the event?	You need this information to understand the sheer magnitude of the improvement effort that is required. Remember we recommend that a cycle time of more than 4 hours may be too much for one single Manufacturing kaizen event. You may have to split it in more than one event. If it is not possible to observe the process during the event, it may be a major barrier to leading a Manufacturing kaizen event.

1.5 Summary

In this chapter the researcher outlined the background of the study. A clear explanation of what manufacturing kaizen is all about was addressed. Factors affecting the success of manufacturing kaizen were also discussed. The difference between value adding and non-value adding activities was also highlighted. The problem statement and the objective of the study were defined by the researcher. The primary objective of the thesis was to study and analyze the cylinder preparation process in APSAP PTY LTD. The secondary objective was to identify waste in the process. Ultimately, the goal of the thesis was to reduce the identified waste using manufacturing kaizen tool.

A preliminary research methodology was discussed. The approach of the research was discussed and explained. Furthermore, the approach layout indicated how the research was constructed to achieve the objective. The chapter also explained the source of data and the method in which the data was collected. An explanation of how the data was analyzed and presented was emphasized. The importance for the approach was to draw an appropriate conclusion from the results. Hence, the validity and reliability of the data and manufacturing kaizen were also discussed. Chapter 2 provided a literature study of manufacturing kaizen and other lean manufacturing tools that can be used to improve processes.

CHAPTER 2

2. Literature review

2.1 Introduction

The literature review in this chapter assists in addressing the research intentions. The use of manufacturing kaizen is a subject that has not been mostly researched in the Africa. Many western companies including some in South Africa have tried to introduce manufacturing kaizen but with little progress. This is indicated by the fact that very few western writers have written much about the manufacturing kaizen concept. Many companies including APSAP PTY LTD have specialized departments dealing specifically with improvements, however the literature introduced in this chapter encompasses world class manufacturing intent but with specific emphasis on manufacturing kaizen tool.

Kaizen is a Japanese word that has become common in many western companies. The word indicates a process of continuous improvement of the standard way of work (Chen et al. 2000). It is a compound word involving two concepts: Kai (change) and Zen (for the better) (Palmer 2001). The term comes from Gemba Kaizen meaning 'Continuous Improvement' (CI). Continuous Improvement is one of the core strategies for excellence in production, and is considered vital in today's competitive environment (Dean & Robinson 1991).

Kaizen calls for endless effort for improvement involving everyone in the organization (Malik & YeZhuang 2006). The ultimate objective of manufacturing industries today is to increase productivity through system simplification, organizational potential and incremental improvements by using modern techniques like Kaizen. Most of the manufacturing industries are currently encountering a necessity to respond to rapidly changing customer needs, desires and tastes. For industries, to remain competitive and retain market share in this global market, continuous improvement of manufacturing system processes has become necessary.

Competition and continuously increasing standards of customer satisfaction has proven to be the endless driver of organizations performance improvement. Kaizen refers to continuous improvement in performance, cost and quality. Kaizen strives to empower the workers, increase worker satisfaction, facilitates a sense of accomplishment, thereby creating a pride of work. It not only ensures that manufacturing processes become leaner and fitter, but eliminate waste where value is added.

Kaizen by now is a widely discussed and applied manufacturing philosophy, in a variety of industries across the globe. Kaizen originated in Japan in 1950 when the management and government acknowledge that there was a problem in the current confrontational management system and a pending labour shortage. Japan sought to resolve this problem in cooperation with the workforce. The groundwork had been laid in the labour contracts championed by the government and was taken up by most major companies, which introduced lifetime employment and guidelines for distribution of benefits for the development of the company.

This contract remains the background for all Kaizen activities providing the necessary security to ensure confidence in the workforce (Brunet 2000). First, it was been introduced and applied by Imai in 1986 to improve efficiency, productivity and competitiveness in Toyota, a Japanese carmaker company in the wake of increasing competition and the pressure of globalization. Since then, Kaizen has become a part of the Japanese manufacturing system and has contributed enormously to the manufacturing success (Ashmore 2001).

Kaizen forms an umbrella that covers many techniques including Kanban, total productive maintenance, six sigma, automation, just-in-time, suggestion system and productivity improvement, etc. (Imai 1986).

2.2 Manufacturing kaizen

Manufacturing kaizen logic was first enshrined in written text with Masaaki Imai's book 'manufacturing kaizen - the key to Japan's competitive success'. This book showed what the fundamental Manufacturing kaizen logic is. Manufacturing kaizen, which is the Japanese word for continuous, endeavor for perfection, has become popular in the west as a paramount concept behind good management. In manufacturing settings, improvements can take place in many forms such as reduction of inventory, and reduction of defective parts.

Manufacturing kaizen uses the Japanese logic of bringing improvements internally from within the workplace; this goes against the European ethics of using external sources such as consultants to improve processes. A company can move closer to perfection by continuously working on improving its current production system by using manufacturing kaizen events or workshops. Manufacturing kaizen is the Japanese idea that "great improvement eventually comes from a series of small incremental gains" (Nicholas 1998). This is the purpose of performing a manufacturing kaizen. The goal is to improve the production process by holding workshops where employees "try to accomplish as much actual manufacturing kaizen as possible" (Shook 1998).

Manufacturing kaizen events have become increasingly popular in recent years and are used by numerous companies to help implement and sustain lean manufacturing principles and practices. Some companies even try to measure success in an organization by counting the number of manufacturing kaizen events held each year (Shook 1998). A prime example of a company which used manufacturing kaizen events to implement lean manufacturing is Freudenberg-NOK. Freudenberg-NOK is the "largest manufacturer of sealing components in the world" (Day 1998). They created a lean production system in 1992, and four years later the company experienced a growth in sales of \$400 million (Day 1998).

The CEO of the company attributed the sales growth to improved quality, cost and delivery which were attained by holding “2,500 manufacturing kaizen events in 15 manufacturing plants” (Day 1998). Other companies however, have had less success with manufacturing kaizen events. (Shook 1998) attributes this lack of success to the way that companies use them. Some companies hold manufacturing kaizen events with the hope that the event will somehow “create a lean production system” (Rother 1998). Manufacturing kaizen by itself does not make a company lean. (Shook 1998) emphasizes some of the pitfalls of manufacturing kaizen events in his article in the book *Becoming Lean*. He explains that companies need to use manufacturing kaizen events as part of the plan for the entire system and not a group of stand-alone activities (Shook 1998).

Manufacturing kaizen events can actually cause problems in a company if they are not part of an overall system (Shook 1998). At the end of a manufacturing kaizen event, there are usually “dozens of niggling problems that don’t surface until after the change” (Rother 1998). Manufacturing companies need to ensure that these problems are dealt with after a manufacturing kaizen event to ensure that the event will have a positive effect on the company and its performance. One of the keys to having successful manufacturing kaizen events is to set up a manufacturing kaizen program.

Some suggestions for having a successful manufacturing kaizen program are to have a lean champion and a governing committee. Ortiz suggest that by hiring an industrial or manufacturing engineer with expertise in lean manufacturing whose sole job is to execute manufacturing kaizen. This person leads the manufacturing kaizen events, is in charge of communicating with others in the organization about the events, and is responsible for following up on the events. Another suggestion by Ortiz is to use an event tracking worksheet to ensure that employees complete any necessary follow-up activities after the manufacturing kaizen event (Ortiz 2006).

A governing committee with managers from each of the business areas is a second recommendation towards an effective manufacturing kaizen event program (Ortiz 2006). The committee would be responsible for scheduling and supporting the manufacturing kaizen events (Ortiz 2006). It is very critical for managers to be involved in manufacturing kaizen events in order to make them effective (Day 1998; Ortiz 2006).

A manufacturing kaizen event can also be viewed as a way to train employees in lean manufacturing and to empower them to create positive changes in their own work areas. At Toyota, manufacturing kaizen events were initially used more as a training tool to instill lean thinking than to actually make company improvements (Shook 1998). It is important to train employees in lean thinking. Employee involvement and empowerment have been shown to be critical in creating a lean production facility (Liker 1998).

This process works in a variety of situations to solve a variety of problems. Kaizen events are often planned using value stream mapping to target the right areas for improvement. Below is a list of some of the problems that can be solved using kaizen events:

- Decreasing changeover time on a piece of equipment or process. Using kaizen, a team can improve upon the time to change over equipment using the SMED system, developed by Shigeo Shingo.
- Organizing the workplace using 5-S.
- Creating a one-piece-flow work cell.
- Developing a pull system.
- Improving equipment reliability through TPM (Total Productive Maintenance).
- Improving the manufacturability of a product design.
- Improving a product development process.
- Improving other administrative processes such as order processing, procurement, engineering change processing and other paperwork/information processing activities.

2.2.1 Manufacturing kaizen benefits

- Problems are identified at source, and resolved.
- Small improvements which are realized can add up to major benefits for the business
- Improvements, which lead to changes in the business quality, cost and delivery of products, mean a greater level of customer satisfaction, and business growth.
- By involving employees in looking at their environment to bring about change, results in improved morale as people begin to find work easier and more enjoyable.

2.2.2 Kaizen logic

In order to implement Manufacturing kaizen, a team needs to be set up to look at a workplace. The employees within the Manufacturing kaizen team need to be trained in manufacturing kaizen logic. The underlying logic of manufacturing kaizen is that it makes employees become aware that by using their skills to improve a process, results in the business becoming more successful, which lends itself to meaning more job security for the employee.

Manufacturing kaizen requires bringing employees together to look at their jobs, sections, and processes, to realize changes that will help performance. Whereas lean manufacturing looked at production issues, manufacturing kaizen can be applied to any business process. Japanese production systems are inherently based on the logic that the employer will always look after the employee, they can be applied to Western companies, but we have to bear in mind the social differences between the cultures and not look merely at short term gains.

Manufacturing kaizen can be a good medium for improving employee-employer relationships. Due to western cultural differences between Japan and the West, it is advisable to have a team leader within your manufacturing kaizen teams. This is to ensure the team behaves as required. Why? Well if a group of closely working together individuals is taken and tell them to stop working and look at their environment, they will need someone to coax and guide them to bring about change, or else the team ethic will disintegrate.

Kaizen events are focused three- to five-day breakthrough events that generally include the following activities:

- Training
- Defining the problem/goals
- Documenting the current state
- Brainstorming and developing a future state
- Implementation
- Developing a follow-up plan
- Presenting results

Kaizen events, however, cannot solve any problem within an organization. There are certain types of improvements for which other methods should be used. Process improvements (such as Six Sigma-type analysis) aimed at yield improvement and variation/scrap reduction are key examples. Suppose that a particular process has a first-pass yield of only 85 percent when it would need to be much closer to 100 percent to run in a one-piece-flow environment. If the process must be analyzed using experiments and statistical methods, it would make sense to utilize a team but not a kaizen event. To implement these types of improvements, a problem-solving team (or a Six Sigma team) that meets regularly over a period of time works better than a kaizen team meeting for five consecutive days.

In order to utilize kaizen events effectively, it is important to understand the types of problems for which kaizen events should and should not be used. With proper planning, kaizen events can bring breakthrough improvement to an organization on its lean journey.

2.3 The 5S

One of the most effective tools that developed from manufacturing kaizen is a continuous improvement tool known as “5S”. This is one of the basis for an effective lean company. 5S consists of the Japanese word Seiri (Sort), Seiton (Straightened), Seiso (Sweep and Clean), Seiketsu (Systemize) and Shitsuke (Standardize). The underlying concept behind 5S is to look for waste and then try to eliminate it. Waste could be in form of scrap, defects, excess raw material, unneeded items, old broken tools, and obsolete jigs and fixtures (Monden 1998).

The first S, Seiri, deals with moving those items that are not currently being used on a continuous basis (e.g., item that will not be used for the next month or so) away from those that are. Moving those items and tossing away needles items will make material flow smoothly, and workers move and work easily (Feld 2000).

Seiton has to do with having the right items in the right area. Items that do not belong to a given area must not be in the area. For a given workplace area tools must be marked and arranged as belonging in that area. This will make it easier to move those items that are not labeled from that area. Arranging items in the right place will make tools, jigs, fixtures, and resources noticeable and easy to use (Feld 2000).

Seiso deals with cleaning and sweeping the work place methodically. The workplace should look neat and clean to use or next shift. The workplace should be maintained on a regular basis (e.g., daily). All tools and items should be in the right place and nothing should be missing. A well-maintain workplace creates a healthy environment to work with (Feld 2000).

Seiketsu is maintaining a high standard of housekeeping and workplace arrangement. A regular audit should be run and scores should be assigned for areas of responsibilities. If every area has people assigned to it then everyone has responsibilities. If every area has people assigned to it then everyone has responsibility to maintain a high standard of housekeeping and cleaning (Feld 2000). Shitsuke is management's accountability to train people to follow housekeeping rules. Management should implement the housekeeping rules in a practical fashion so that their people can buy into it. Management should walk the shop floor, explain what they want from people, reward those who follow and instruct those who do not (Feld 2000). Taken together, 5S means good housekeeping and better workplace organization. Manufacturing kaizen tools such as 5S are not only a means to increase profitability of a firm but also allow companies to reveal potential strengths and capabilities that were hidden before.

2.4 What is Lean?

The new uprising in the manufacturing goods and services sector has created great challenges for most industries. The customer driven and highly competitive market has rendered the old-fashioned managerial style an inadequate tool to cope with challenges. These factors present a big challenge to companies to look for new tools to continue moving up the ladder in a global, competitive and growing market. While some companies continue to grow based on economic constancy, other companies struggle because of their lack of understanding of the change in customer mind-sets and cost practices. To get out of this situation and to become more profitable, many manufacturers have started to turn to lean manufacturing principles to elevate the performance of their firms.

The basic ideas behind the lean manufacturing system, which have been practiced for many years in Japan, are cost reduction, employee empowerment and waste elimination, such as longer waiting times, unnecessary interruptions, searching times, unnecessary inspections, movements and set up times. The Japanese philosophy of doing business is totally different than the philosophy that has been long prevalent in most of the countries. The traditional beliefs in the west had been that the only way to make profit is to add it to the manufacturing cost to come up with a desired selling price (Ohno 1997; Monden 1998).

On the contrary, the Japanese approach believes that the customers are the generator of the selling price. The more quality one builds into the product and the more service one offers, the more the price that the customer will pay. The difference between the cost of the product and this price is what determines the profit (Ohno 1997; Monden 1998).

The lean manufacturing discipline is to work in every facet of the value stream by eliminating waste in order to reduce cost, generate capital, bring in more sales, and remain competitive in growing the global market. The value stream is defined as “the specific activities within a supply chain required to design, order and provide a specific product or value” (Hines & Taylor 2000)

The term “lean” as Womack and his colleagues define it denotes a system that utilizes less, in term of all inputs, to create the same outputs as those created by a traditional mass production system, while contributing increased varieties for the end customer (Panizzolo 1998). This business philosophy goes by different names. Agile manufacturing, just-in-time manufacturing, synchronous manufacturing, world-class manufacturing and continuous flow are all terms that are used in parallel with lean manufacturing.

So the resounding principle of lean manufacturing is to reduce cost through continuous improvement that will eventually reduce the cost of services and products, thus growing more profit. "Lean" focuses on abolishing or reducing wastes and on maximizing or fully utilizing activities that add value from the customer's perspective. From the customer's perspective, value is equivalent to anything that the customer is willing to pay for in a product or service that follows. According to (Womack et al. 1990; Ohno 1997; Monden 1998; Shingo 1997; Mid-America Manufacturing Technology Center 2000), the elimination of waste is the basic principle of lean manufacturing. For industrial companies, this could involve any of the following:

- Material: Convert all raw materials into end products. Try to avoid excess raw materials and scrap.
- Inventory: Keep constant flow to the customer and to not have idle material.
- Overproduction: Produce the exact quantity that the customer need, and when they need it.
- Labour: Get rid of unwanted movement of people.
- Complexity: Try to solve problems the uncomplicated way rather than the complex way. Complex solutions tend to produce more waste and are harder for people to manage.
- Energy: Utilize equipment and people in the most productive ways. Avoid unproductive operations and excess power utilization.
- Space: reorganize equipment, people, and workings-stations to get a better space arrangement.
- Defects: Make every effort to eliminate defects.
- Transportation: Get rid of transportation of materials and information that does not add value to the product.
- Time: Avoid long setups, delays and unexpected machine downtime.
- Unnecessary Motion: Avoid excessive bending or stretching and frequently los items.

Waste resources are all related to each other and getting rid of one source of waste can lead to either elimination of, or reduction in others. Perhaps the most significant source of waste is inventory. Work-in-progress and finished parts inventory do not add value to a product and they should be eliminated or reduced. When inventory is reduced, hidden problems can appear and actions can be taken immediately.

There are many ways to reduce the amount of inventory, one of which is reducing production lot sizes. Reducing of lot sizes however, should be followed by a setup time reduction so as make the cost per unit constant as the famous economic order quantity formula states (Karlsson & Ahlstrom 1996). At Toyota, Shingo developed the concept of single minute exchange of dies (SMED) to reduce set up times (Shingo 1997); for instance, setup times in large punch presses could be reduced from hours to less than ten minutes.

This has a big effect on reducing lot sizes. Another way to reduce inventory is by trying to minimize machine downtime (Shingo 1997). This can be done by preventive maintenance. It is clear that when inventory is reduced other sources of waste are reduced too. For example, space that was used to keep inventory can be utilized for other things such as to increase facility capacity. Also, reduction in setup times as means to reduce inventory simultaneously saves time, thus reduces time as a source of waste.

Transportation time is another source of waste. Moving parts from one end of the facility to another end does not add value to the product. Thus, it is important to decrease transportation times within the manufacturing process. One way to do this is to utilize a cellular manufacturing layout to ensure a continuous flow of the product. This also helps eliminate one other source of waste, which is energy.

When machines and people are grouped into cells, unproductive operations can be minimized because a group of people can be fully dedicated to that cell and this avoids excess human utilization. Another source of waste is defects and scrap materials. Total productive maintenance is one way to eliminate defects and scrap. Manufacturing parts that are fault-free from the beginning had profound consequences for productivity (Hays & Clark 1986).

There is no question that the elimination of waste is an essential ingredient for survival in today's manufacturing world. Companies must strive to create high-quality, and low cost products that can get to the customers in the shortest time possible. There are set of tools that were developed at Toyota and that can be utilized to eliminate or at least reduce the source of waste.

2.5 The history of Lean manufacturing

Lean manufacturing is another word for continuous improvement, a term used to describe a manufacturing system that is primarily based on the Toyota Production System (Black & Hunter 2003). The Toyota Production System (TPS) is a business strategy that was developed by Taiichi Ohno in the early 60's (Black & Hunter 2003). The goal of this strategy was to reduce inventory and improve the quality and cost of Toyota's automobiles. As a result of this unique production system, Toyota became a leading automobile manufacturer (Black & Hunter 2003).

Other companies took notice, and the TPS became one of the most benchmarked production systems in the world (Black & Hunter 2003). After World War II Japanese manufactures were faced with the dilemma of vast shortage of material, financial, and human resources. The problems that Japanese manufacturers we faced with differed from those of their Western counterparts. These conditions resulted in the birth of the "lean" manufacturing concept.

Toyota Motor Company, led by its president Toyoda recognized that American automakers of that era were out-producing their Japanese counterparts by a factor of ten. In order to make a move towards improvement early Japanese leaders such as Toyoda Kiichiro, Shiegeo Shingo and Taiichi Ohno devised a new disciplined, process-oriented system, which is today known as the "Toyota production system" or "lean manufacturing". Taiichi Ohno, who was given the task of developing the system that would enhance productivity at Toyota, is generally considered to be the primary force behind this system.

Ohno drew upon some ideas from the West and particularly from Henry Ford's book "Today and Tomorrow". Ford's moving assembly line of continuously flowing material formed the basis of the Toyota Production System. After some experimentation, the Toyota production system was developed and refined between 1945 and 1970, and is still growing all over the world. The basic underlying idea of this system is to minimize the consumption of resources that add no value to a product.

In order to compete in today's fiercely competitive market, US manufacturers have come to realize that the traditional mass production concept has to be adopted to the new ideas of lean manufacturing. A study that was done at the Massachusetts Institute of Technology of the movement from mass production toward lean manufacturing, as explained in the book "the machine that changed the world" (Womack, Jones & Ross 1990), which awoke the US manufacturers from their sleep. The study underscored the great success at NUMMI (New United Motor Manufacturing Inc.) and brought out the huge gap that existed between the Japanese and Western automotive industry.

The ideas came to be adopted in the US because the Japanese companies developed, produced and distributed products with half or less human effort. This includes capital investment, floor space, tools, materials, time, and overall expense (Womack et al. 1990). Many companies in the United States have tried to create production systems that are largely based on the concepts and ideas brought about by Toyota.

A few examples include the Ford Production System, the Chrysler Operation System, and Growth which is the lean production system for a German company called Freudenberg-NOK (Shook 1998; Day 1998).

These are all modern production systems based on TPS. All of these companies have benchmarked TPS because it has been very successful, and it is drastically different from traditional mass manufacturing methods. Lean manufacturing focuses on the customer rather than on the product. The entire purpose of lean manufacturing is to eliminate muda or waste, the Japanese term for waste (Womack & Jones 1996).

Waste is considered to be any activity that absorbs resources without adding value to the product (Womack & Jones 1996). Value is defined by the customer and therefore the goal is to eliminate all processes or activities which do not add value in the eyes of the customer. The basic concept of lean is simple, but sometimes it is hard to grasp exactly how to use this concept to improve a production system. One way to think about lean manufacturing is to break it up into different lean principles, which are called value, the value stream, flow, pull, and perfection (Womack & Jones 1996).

2.5.1 Value and value stream

The first two principles of lean manufacturing focus on the value of a product from the eyes of the customer. Many companies focus on their own “operational ‘efficiency’” and not on delivering a sound product to the customer (Womack & Jones 1996). Lean manufacturing stresses the importance of looking at a product from the customer’s point of view.

Then, from there, one can determine what parts of the manufacturing process are directly adding value to the product and which parts are not. The manufacturing processes that do not add value to the product are then eliminated.

2.5.2 Flow and Pull

The next key principle in lean manufacturing is to ensure that all of the remaining steps in the process flow together (Womack & Jones 1996). This principle can be interpreted as a recommendation to arrange the manufacturing steps in such a way that makes the most sense. It is more efficient and accurate to work on a product “continuously from raw material to finished good” than to handle the product multiple times using batch flow (Womack & Jones 1996). The fourth lean principle introduced in lean thinking is pull. The idea behind pull is relatively simple. In order to avoid overproduction, do not make a product until a customer orders it. Let the customer pull the product from the manufacturer when they want it.

2.5.3 Perfection

The final principle of lean production is perfection (Womack & Jones 1996). Perfection simply means that the process is never entirely complete and that it is essential that companies continuously work to improve the production process. The ultimate goal is to make the production process perfect. However, due to changing customer needs, the production process will never be perfect, and a company must continuously improve the production process to ensure that it is always as close to perfection as possible.

2.6 Other Lean Manufacturing Tools and Techniques

Once companies pinpoint the major sources of waste, tools such as continuous improvement, just-in-time production, production smoothing and other others will guide companies through corrective actions so as to eliminate waste. In the following section a brief description of such tools are given.

2.6.1 Cellular Manufacturing



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Organizations are currently encountering a necessity to respond to rapidly changing consumer needs, desires, and tastes. To compete in this continuously changing environment, these organizations must seek out new methods allowing them to remain competitive and flexible simultaneously, enabling their companies to respond rapidly to new demands. The contemporary industrial world is in a new era termed the "third industrial revolution" (Black 1991). The effect of this new era is dramatic to most businesses because they have been forced into the global economy by emerging global competition. In order for companies to remain competitive, retain their market share in this global economy, and satisfy both external and internal customers, continuous improvement of manufacturing system processes has become necessary (Kokuo 1992; Shingeo 1988; Yaruhiro 1993).

The method used to design a flexible, unique, controllable, and efficient cellular manufacturing system has become a topic that modern industrial operations are eager to learn and implement. The Kaizen technique has been proven as an effective tool for process improvement (Yung 1996), process reengineering (Lyu 1996), and even for organizational designs (Berger 1997). Kaizen now is further implemented in industries for designing cellular manufacturing system to reduce cost and working space

Cellular manufacturing is one the cornerstone when one wants to become lean. It is a concept that increases the mix of products with the minimum waste possible. A cell consists of equipment and workstations that are arranged in an order that maintains a smooth flow of materials and components through the process. It also has assigned operators who are qualified and trained to work at that cell. Arranging people and equipment into cells has great advantage in terms of achieving lean goals.

According to (Suresh & Meredith 1994), one of the advantages of cell is the one-piece flow concept, which state that each product moves through the process one unit at the time without sudden interruptions, at a pace determined by the customer's need. Extending the product mix is another advantage of cellular manufacturing. When the customer demand a high variety of products as well as faster delivery rates, it is important to have the flexibility in the process to accommodate their need. This flexibility can be achieved through grouping similar products into families that can be processed on the same equipment in the same sequence.

This also shortens the time required for changeover between products, which will encourage production in smaller lots. Other benefits associated with cellular manufacturing include (Suresh & Meredith 1994):

- Inventory (especially WIP) reduction
- Reduces transport and material handling
- Better space utilization
- Lead time reduction
- Identification of causes of defects and machine problems
- Improved productivity
- Enhanced teamwork and communication
- Enhanced flexibility and visibility

An example of the successful implementation of kaizen in junction with cellular manufacturing is the case of a U.S. wood window company in the state of Iowa. This company has been using kaizen since 1991 to redesign their shop floor, replacing expensive, nonflexible automation with low cost, highly flexible cellular applications. This company uses kaizen to respond rapidly to consumer needs and to resolve problems in their manufacturing processes. Kaizen is used extensively in product, process, and production development. The major strategy of this development was to design a new product while considering the functions of products, the production processes used, and efficient production practices on the shop floor.

Kaizen called for the creation of a team that includes cross-functional employees, such as engineers, shop managers, and operators, working together on targeted areas. With a set of goals and a series of brainstorming processes, this team is expected to obtain a solution for resolving the problem within a week's time.

The wood window company has successfully undertaken hundreds of projects over the past eight years. Achieving success in this way, the company has become a model for many local industries. Kaizen's successes in this pull cellular manufacturing system and address this success in terms of cost, space, and improved worker satisfaction. The kaizen process is successful because it employs the lean thinking approach of designing a flexible, controllable, efficient, and unique manufacturing process (Womack & Jones 1996).

2.6.2 Just-In-Time

Closely associated with lean manufacturing is the principle of just-in-time, since it is a management idea that attempts to eliminate source of manufacturing waste by producing the right part in the right place at the right time. This addresses waste such as work-in-process material, defects and poor scheduling of parts delivered (Nahmias 1997). Inventory and material flow systems are typically classified as either push (traditional) or pull (just-in-time) system.

Customer demand is the driving force behind both systems. However, the major difference is in how each system handles customer demand. Just-in-time is a tool that enables the internal process of a company to adapt to sudden changes in the demand pattern by producing the right product at the right time, and in the right quantities (Monden 1998). Moreover, just-in-time is a critical tool to manage the external activities of a company such as purchasing and distribution. It can be thought of as consisting of three elements: JIT production, JIT distribution and JIT purchasing. More details are given for each in the following sections.

2.6.2.1 Just-In-Time Production. Lean manufacturing is about eliminating waste wherever it is. One of the most important steps in the implementation of lean manufacturing is JIT. (Monden 1998; Levy 1997) both agree that JIT production is the backbone of lean manufacturing. Just-in-time production is about not having more raw material, work in process or products than what are required for smooth operation.

JIT utilizes what is known as a “pull system”. Customer demand, which is the generator of the order, sends the first signal to production. As a result, the product gets pulled out of the assembly process. The final assembly line goes to the preceding process and pulls or withdraws the necessary parts in the necessary quantity at the necessary time (Monden 1998).

The process goes on as each process pulls the needed parts from the preceding process further up stream. The whole process is coordinated through the use of a kanban system. Shipments under JIT are small, frequent lots. Kanban is used to manage these shipments. Kanban is an information system that is used to control the number of part to be produced in every process (Monden 1998). The most common types of kanban are the withdrawal kanban, which specify the quantity that the succeeding process should pull from the preceding process, and the production kanban, which specifies the quantity to be produced by the preceding process (Monden 1998).

A supplier kanban is another type of kanban that is used between the supplier and the manufacturer under JIT. Lean manufacturing requires quick deliveries and in order to achieve this, many manufacturers require their suppliers to deliver items just in time. In order to achieve JIT delivery, suppliers have to adjust from the traditional run sizes to smaller lot size. The supplier kanbans circulate between the manufacturer and the supplier.

The kanban is delivered at predefined times from the manufacturer to the supplier. For example, if parts were conveyed twice a day (8 a.m and 10 p.m), the truck driver would deliver the kanban at the supplier’s store at 8 a.m. which is a signal to the supplier to produce the required quantity. At the same time the driver picks up the parts that are completed at 8 a.m. that morning along with the kanban attached to the boxes containing these parts. These are kanbans that would have arrives the previous night at 10 p.m. signaling the production of the parts (Monden 1998).

By utilizing a kanban system under JIT, smaller lots sizes and huge inventory reductions can be achieved. Under JIT production raw material, subassemblies and finished product inventory are kept to a minimum and lean principles are followed to eliminate inventory as a source of waste. Another type of waste that is eliminated under JIT production is overproduction. Since every process is producing at a pace no higher than that of the subsequent process's requirement, the need to produce more than what is needed is diminished.

2.6.2.2 Just-In-Time Distribution: JITD effectiveness depends heavily on having a strategic alliance between buyers and suppliers. By having a third-party logistics distributor, companies can focus on their core competencies and areas of expertise leaving the logistics capability to logistics companies (Simchi-Levi et al. 2000; Quinn & Hilmer 1994). Third-party logistics refers to the use of an outside company to perform all or part of the firm's materials management and product distribution functions (Simchi-Levi et al. 2000).

JITD requires the exchange of frequent, small lots of items between suppliers and customers, and must have an effective transportation management system because the transportation of inbound and outbound material can have a great effect on production when there is no buffer inventory (Spencer, Daugherty & Rogers 1994). Under JITD having a full truck load sometimes is difficult due to the frequent delivery of smaller lots, which in turn will increase the transportation cost. However, to get over the problem (Monden 1998) states that instead of having one part loading, using a mixed loading strategy makes it possible to have full truckload and increases the number of deliveries.

Another important factor that is essential to JITD is EDI. Electronic data interchange (EDI) is the structured transmission of data between organizations by electronic means. It is used to transfer electronic documents or business data from one computer system to another computer system, i.e. from one trading partner to another trading partner without human intervention. In order to have effective product deliveries between suppliers and their distributors or customers, an EDI system must be in place.

In the traditional product delivery system suppliers always have to keep finished goods inventory or have to alter their production schedules to respond to demand surges. Under EDI suppliers can look at all the shipment and inventory data and adjust their production schedule accordingly (Simchi-Levi et al. 2000). To stay competitive under JITD, it is very important to share information in the whole supply chain because suppliers can adjust their production schedules and narrow their delivery window as more product data become available to them. Other benefits of EDI include cost reduction, cycle time reduction, stock out reduction and inventory reduction.

2.6.2.3 Just-In-Time Purchasing: (Ansari & Mondarress 1986) and (Gunasekaran 1999) define just-in-time purchasing (JITP) as the purchase of goods such that their delivery immediately precedes their demand, or they are required for use. The idea of JITP runs counter to traditional purchasing practices where material are bought well in advanced before their use. Under JITP activities such as supplier selection, product development and production lot sizing become very critical. Customer supplier relationships are very important part of JITP.

Under JITP it is necessary to have a small number of qualified suppliers. Having certified suppliers shifts the inspection function of quality and piece by piece count of parts to the supplier's site where the supplier must take that parts are defect free before they are transported to the manufacture's plant. EDI is very important under JITP. The ultimate goal of JITP is to guarantee that the production is as close as possible to continuous process from the raw material reception until the distribution of the finished good (Gunasekaran 1999).

EDI can support JITP by reducing the transaction processing time and meeting the specialized needs of buyers by helping them to synchronize their material movement with their suppliers. Although under JITP the carrying cost of material is increased due to frequent small slots, this is offset by a decrease in the cost of processing a purchase order and by the decrease inventory holding cost.

According to (Nahmaias 1997), some of the benefits of JIT are:

- Eliminating unnecessary work-in-process, this results in reduction of inventory costs.
- Since units are produced only when they are needed, quality problem can be detected early.
- Since inventory is reduced, the waste of storage space will be reduced.
- Preventing excess production can uncover hidden problems.

Another important factor of JITP is product development. Buyers must have “Black Box” relationship. This is where suppliers and clients participate heavily in design and development. The following figure presents the typical interactions between a client and a supplier server.

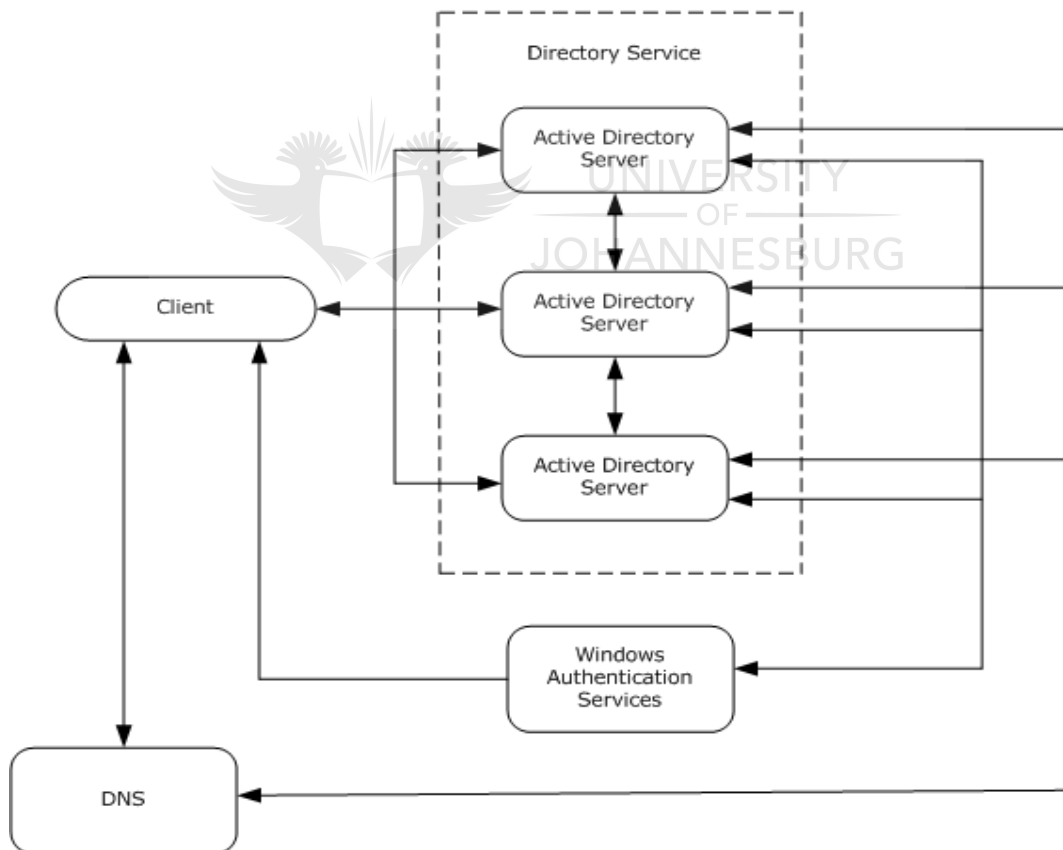


Figure 1: Generalized request/response operation sequence (2000).

The benefits of sharing new product development and design innovation include a decrease in purchased material cost, increase in purchased material quality, and a decrease in development time and cost and in manufacturing cost, and an increase in final product technology levels (Semchi-Levi et al. 2000).

2.6.2.4 Production Smoothing

In a lean manufacturing system it is important to move to higher degree of process control in order to strive to reduce waste. Another tool to accomplish this is production smoothing. Heijunka is the Japanese word for production smoothing; it is where the manufacturers try to keep the production level as constant as possible for day to day (Womack et al. 1990).

Heijunka is a concept adopted from Toyota production system, where in order to decrease production cost it was necessary to build no more cars and parts than the number that could be sold. To accomplish this, the production schedule should be smooth so as to effectively produce the right quantity of parts and efficiently utilize manpower. If the production level is not constant this leads to waste (such as work-in-process inventory) at the workplace.

Production smoothing and planning deal with the setting of production, inventory, and work force levels to satisfy demand requirements over a medium-term planning horizon. The need for production planning results primarily from aggregate demand fluctuations, such as those that occur for seasonal product families. There has been an extensive management science effort developing decision models to support this planning process. Both (Silver 1967; Hax 1978) provide excellent surveys and critiques of this body of work. A typical scenario addressed by management scientists has been one in which the following strategies exist for meeting demand requirements:

- varying the aggregate production level to meet anticipated fluctuations in demand while keeping inventory levels constant. The production level is varied by changing the work force level and/or by using overtime,
- varying the inventory levels to handle anticipated fluctuations in demand while keeping the aggregate production level constant and equal to the average aggregate demand rate,
- a mixture of both strategies

By associating costs to the consequences of each strategy and by identifying constraints on the production planning decisions (such as satisfying forecasted demand over the planning horizon), the management scientist can then formulate a mathematical model with decision variables being the production, inventory, and work force levels, and with a criterion of production, inventory, and work force costs. The model's solution would determine the production planning decisions that minimize total costs.

2.6.2.5 Standardization of work

A very important principle of waste elimination is the standardization of worker actions. Standardization work basically ensures that each job is organized and is carried out at most effective manner. No matter who is doing the job the same level of quality should be achieved. At Toyota every worker follows the same processing steps all the time. This includes the time needed to finish the job, and the parts on hand. By doing this one ensures that the balancing is achieved, unwarranted work-in-process inventory is minimized and non-value added activities are reduced.

Standardised operations are the backbone of continuous improvement (kaizen) systems, yet we continue to overlook this lean technique. Put simply, standardised work is the documentation and application of good work (your best practices) from a process by process perspective. Standardised processes provide companies with a stable basis from which to measure continuous improvement. This is the minimum standard of work from which you can start continuous improvement (Kaizen) activity.

A standard operating procedure is a set of instructions that provide direction covering those features of processes that lend themselves to a definite or standardised approach for optimisation and consistency of output. These work procedures are completed by committed cross functional work teams and encourages contribution of experience, knowledge, accuracy and ideas for constant improvement. Well-written standardised work procedures provide direction, improve communication, improve efficiency, improve safety, improve quality, improve capacity, reduce training time, and improve work consistency. The SOP development process is an excellent way for managers, workers, and technical advisers to cooperate for everyone's benefit.

2.6.2.5.1 Benefits of standardization of work

The development and use of SOPs minimizes variation and promotes quality through consistent implementation of a process or procedure within the organization, even if there are temporary or permanent personnel changes. It minimizes opportunities for miscommunication and can address safety concerns. When historical data are being evaluated for current use, SOPs can also be valuable for reconstructing project activities when no other references are available. In addition, SOPs are frequently used as checklists by inspectors when auditing procedures. Ultimately, the benefits of a valid SOP are reduced work effort, along with improved comparability, credibility, and legal defensibility (American Society for Quality 2004).

SOPs should be written in a concise, step-by-step, easy-to-read format. The information presented should be unambiguous and not overly complicated. The active voice and present verb tense should be used. The term "you" should not be used, but implied. The document should not be wordy, redundant, or overly lengthy. Keep it simple and short. Information should be conveyed clearly and explicitly to remove any doubt as to what is required. Also, use a flow chart to illustrate the process being described. In addition, follow the style guide used by your organization, e.g., font size and margins(American Society for Testing and Materials, ASTM D 5172-91 2004).

SOPs can also be developed from process maps. Process mapping is a technique for visually representing a standardized process, breaking it down into constituent parts. The challenge then, is to identify all the steps and decisions in a process in diagrammatic form, capturing: -

- the flow of information, documents, or materials
- tasks within the process that transform inputs into outputs
- where decisions need to be made along the chain
- dependencies between the process steps

Outline process maps (or flowcharts) show all the actions undertaken, providing a dynamic view of how your organisation can deliver enhanced business value (e.g. improved quality outcomes in clinical research). Through using “what if scenarios” you can compare maps of the process “as is” with the process “to be”. Swimlane flowcharts (otherwise known as deployment charts), represent actions according to where, or by whom, they’re performed.

Either method, of representing the component parts in a process, simplifies SOP content into a large-scale format, which makes it easier to convert into a written SOP. As a team exercise, ideally, process mapping leads to communication between departments or functions with an open exchange of ideas, plugging gaps and eliminating overlaps. At the very least, as a basis for SOP development, it provides a common framework, introducing a systematic way of working, which is after all, a necessary part of standardisation.

Coined by Hammer and Champy, ‘business process reengineering’ (BPR) is defined as *“the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures such as cost, quality, service, and speed”* (Siha & Saad 2008). Many organizations have turned to BPR to improve their competitive position through simplification, elimination and redesign of business processes for increased efficiency and cost reduction; leading to an increase in the number of BPR projects undertaken (Soliman 1998).

As summarized by (Al-Mashari & Zairi 2000), “a business process has structure, inputs, outputs, customers and owners, and is built up by integrating fragmented functions that contribute to its operations and internal and external flows”. Key elements of the business process model are people (i.e. skills, attitude and culture required), the information technology (IT) system (i.e. software and hardware to support information flow), technology (i.e. facilities and equipment required), process (i.e. activities required to achieve critical success factors), infrastructure (i.e. layout, material flow, etc.), and organization (i.e. the structure required to operate the process (Wu et al. 2010).

The most important and fundamental element of BPR is business process mapping (Soliman, 1998). Process mapping is a technique used to detail business processes through a graphical description of business activities and flows by focusing on the important elements that influence their actual behavior. As described by (Siha & Saad 2008), *“Process mapping offers a ‘visual 5 aid’ to process improvement and provides a means for analyzing the process...It is a framework that shows relationships between the activities, people, data and objectives”*.

According to (Soliman 1998), process mapping is usually performed over 3 steps:

1. Identifying products and services and their related processes, including starting and finishing points of processes.
2. Data gathering and preparation.
3. Transforming the data into a visual representation in order to identify bottlenecks, wasted activities, delays and duplication of efforts.

2.6.2.6 Total Productive Maintenance

Total productive maintenance (TPM) originated in Japan in 1971 as a method for improved machine availability through better utilization of maintenance and production resources. Whereas in most production settings the operator is not viewed as a member of the maintenance team, in TPM the machine operator is trained to perform many of the day-to-day tasks of simple maintenance and fault-finding. Teams are created that include a technical expert (often an engineer or maintenance technician) as well as operators. In this setting the operators are enabled to understand the machinery and identify potential problems, righting them before they can impact production and by so doing, decrease downtime and reduce costs of production (Nakajima 1989).

TPM is a critical adjunct to lean manufacturing. If machine uptime is not predictable and if process capability is not sustained, the process must keep extra stocks to buffer against this uncertainty and flow through the process will be interrupted. Unreliable uptime is caused by breakdowns or badly performed maintenance. Correct maintenance will allow uptime to improve and speed production through a given area allowing a machine to run at its designed capacity of production.

TPM is a management process developed for improving productivity by making processes more reliable and less wasteful. The objective of TPM is to maintain the plant or equipment in good condition without interfering with the daily process. To achieve this objective, preventive and predictive maintenance is required. By following the philosophy of TPM we can minimize the unexpected failure of the equipment (Nakajima 1989).

TPM focuses primarily on manufacturing (although its benefits are applicable to virtually any "process") and is the first methodology Toyota used to improve its global position (1950s). After TPM, the focus was stretched, and also suppliers and customers were involved (supply chain), this next methodology was called lean manufacturing.

An accurate and practical implementation of TPM, will increase productivity within the total organization, where (Nakajima 1989) :

- (1) a clear business culture is designed to continuously improve the efficiency of the total production system
- (2) a standardized and systematic approach is used, where all losses are prevented and/or known.
- (3) all departments, influencing productivity, will be involved to move from a reactive- to a predictive mindset.
- (4) a transparent multidisciplinary organization in reaching zero losses.
- (5) steps are taken as a journey, not as a quick menu.

Machine breakdown is one of the most important issues that concern the people on the shop floor. The reliability of the equipment on the shop floor is very important since if one machine breaks down the entire production line could go down. An important tool that is necessary to account for sudden machine breakdowns is total productive maintenance. In almost any lean environment setting a total productive maintenance program is very important.

There are three main components of a total productive maintenance program: (1) preventive maintenance, (2) corrective maintenance and (3) maintenance preventive.

(1) Preventive maintenance has to do with regular planned maintenance on all the equipment rather than random check ups. Workers have to carry out regular equipment maintenance to detect any anomalies as they occur. By doing so sudden machine breakdown can be prevented, which leads to improvement in the throughput of each machine (Feld 2000). (2) Corrective maintenance deals with decision such as whether to fix or buy new equipment. If a machine is always down and its components are always breaking down then it is better to replace those parts with newer ones. As a result the machine will last longer and its uptime will be higher (Feld 2000). (3) Maintenance prevention has to do with buying the right machine. If a machine is hard to maintain (e.g., hard to lubricate or bolts are hard to tighten) then workers will be reluctant to maintain the machine on a regular basis, which will result in a large amount of lost money invested in that machine (Feld 2000).

(Dhillon & Liu 2006) separates maintenance and categorize them as: preventive, corrective and predictive maintenance.

Preventive maintenance is often referred to as planned maintenance and is carried out regularly or after inspection in order to keep the equipment in working condition (Dhillon & Liu 2006). Preventive maintenance can be defined as follows: Actions performed on a time- or machine-run-based schedule that detect, preclude, or mitigate degradation of a component or system with the aim of sustaining or extending its useful life through controlling degradation to an acceptable level.

The U.S. Navy pioneered preventive maintenance as a means to increase the reliability of their vessels. By simply expending the necessary resources to conduct maintenance activities intended by the equipment designer, equipment life is extended and its reliability is increased. In addition to an increase in reliability, dollars are saved over that of a program just using reactive maintenance. Studies indicate that this savings can amount to as much as 12% to 18% on the average. Depending on the facilities current maintenance practices, present equipment reliability, and facility downtime, there is little doubt that many facilities purely reliant on reactive maintenance could save much more than 18% by instituting a proper preventive maintenance program (Dhillon & Liu 2006).

While preventive maintenance is not the optimum maintenance program, it does have several advantages over that of a purely reactive program. By performing the preventive maintenance as the equipment designer envisioned, we will extend the life of the equipment closer to design. This translates into dollar savings. Preventive maintenance (lubrication, filter change, etc.) will generally run the equipment more efficiently resulting in dollar savings. While we will not prevent equipment catastrophic failures, we will decrease the number of failures. Minimizing failures translate into maintenance and capital cost savings.

Corrective maintenance is done to return the equipment to working condition after breakdown or after perceived deficiencies (Dhillon & Liu 2006). Lastly (Dhillon & Liu 2006) describe predictive maintenance as using technology to diagnose items' or equipments condition during operation. Predictive maintenance can also be the process of gathering information about the state of the equipment (Niebel 1994). The information gathered is then used to plan and schedule maintenance.

Preventive and predictive maintenance is closely related and are because of this often treated in a similar way, which is also the case in the literature that have been used in this report. According to (Salonen & Deleryd 2011), preventive maintenance can be regarded as value adding while corrective maintenance is regarded as waste. This relates to the fact that facilities and machinery need regular maintenance to function in an optimal way. However, stops due to breakdowns can relate to lack of preventive maintenance, human error or other kinds of problems that can be avoided and hence are considered as waste.

Corrective maintenance is more costly than preventive since preventive can be planned and therefore be executed at a preferred time and date (Campbell & Jardine 2001). Corrective maintenance also implies that a company needs to quickly find material and personnel for reparation which, according to (Campbell & Jardine 2001), increases the cost. (Campbell & Jardine 2001) present a rule of thumb where corrective maintenance in general cost 50 % more than planned stops and breakdowns cost 200 % more than planned stops. The cost aspect is a driving factor for producing companies to shift from corrective to preventive maintenance.

2.6.2.7 Brainstorming

Brainstorming is a tool used by teams to bring out the ideas of each individual and present them in an orderly fashion to the rest of the team. Brainstorming is useful when you want to generate a large number of ideas about issues to tackle, possible causes of problems, approaches to use, or actions to take. The key ingredient is to provide an environment free of criticism for creative and unrestricted exploration of options or solutions. Brainstorming helps a team break free of old, ineffective ideas. This free-wheeling technique for generating ideas may produce some that seem half-baked, but it can lead to new and original solutions to problems. Some of the specific benefits of Brainstorming are (Brassard 1988):

- Encourages creativity. It expands your thinking to include all aspects of a problem or a solution. You can identify a wide range of options.
- Rapidly produces a large number of ideas. By encouraging people to offer whatever ideas come to mind, it helps groups develop many ideas quickly.
- Equalizes involvement by all team members. It provides a nonjudgmental environment that encourages *everyone* to offer ideas. All ideas are recorded.
- Fosters a sense of ownership. Having all members actively participate in the Brainstorming process fosters a sense of ownership in the topic discussed and in the resulting activities. When the people on a team contribute personally to the direction of a decision, they are more likely to support it.
- Provides input to other tools. You may want to affinities the brainstormed ideas. And, if appropriate, you can work with the team to reduce the number of ideas by multi-voting.

For all participants to enjoy a creative and productive Brainstorming experience, the facilitator needs to review and get team members' buy-in on the ground rules for the session. These are the rules:

- Active participation by all team members. Everyone expresses his or her ideas, even if they seem silly or far out.
- No discussion—criticisms, compliments, or other comments—during the brainstorm.
- Build on ideas generated by other team members.
- All ideas written exactly as presented and displayed where everyone can see them.
- Set a time limit.

After the brainstorm, the facilitator goes over the list to make sure that all team members understand the ideas and see whether two or more ideas that appear to be the same can be combined. The recommended sequence for conducting brainstorming and some suggestions for conducting the session effectively are provided below (Department of the Navy 1992):

- Review the rules for Brainstorming. Describe how this session will be conducted by going over the points below.
- Set a time limit for Brainstorming, assign a timekeeper and data recorder, and start the clock. Brainstorming should be a rapid generation of ideas, so do it quickly; 5-15 minutes works well. If the time limit has expired and ideas are still being generated, you can extend the time limit at five-minute intervals.
- State the topic to be brainstormed in the form of a question. Write it down and post it where everyone can refer to it. Ensure that everyone understands it.

After allowing a few minutes for the participants to think about the question, the facilitator ask them to give their ideas. This could be either in a structured or unstructured format. The structured format involves the facilitator establishing a rotation that enables each person in the group to contribute an idea in turn. Any individual who is not ready with an idea when his or her turn comes can pass until the next round, when he or she may offer an idea or pass again.

The unstructured format allows the team members to call out ideas as they come to mind. This method calls for close monitoring by the facilitator to enforce the ground rules and ensure that all team members have a chance to participate (Scholtes et, al. 1988). Ideas are recorded on a chart pack as they are called out, or collect ideas written by team members on post-its and displayed where everyone can see them. Having the words visible to everyone at the same time avoids misinterpretation and duplication and helps stimulate creative thinking by other team members.

2.6.2.8 Action plan template

In some ways, an action plan is a "heroic" act: it helps us turn our dreams into a reality. An action plan is a way to make sure your organization's vision is made concrete (Barry 1994). It describes the way the team will use its strategies to meet its objectives. An action plan consists of a number of action steps .:

- What actions or changes will occur
- Who will carry out these changes
- By when they will take place, and for how long
- What resources (i.e., money, staff) are needed to carry out these changes
- Communication (who should know what?)

Ideally, an action plan should be developed within the first six months to one year of the start of an organization (Bryson 1988). It is developed after the organisation has determined the vision, mission, objectives, and strategies. An action plan will provide a blueprint for running an organization or initiative. There is an inspirational adage that says, "People don't plan to fail. Instead they fail to plan." Because you certainly don't want to fail, it makes sense to take all of the steps necessary to ensure success, including developing an action plan (Berkowitz 1982). There are lots of good reasons to work out the details of your organization's work in an action plan. They include:

- To lend credibility to your organization. An action plan shows members of the community that your organization is well ordered and dedicated to getting things done.
- To be sure you don't overlook any of the details
- To understand what is and isn't possible for your organization to do
- For efficiency: to save time, energy, and resources in the long run
- For accountability: To increase the chances that people will do what needs to be done.

2.6.2.9 Other Waste Reduction Techniques

Some of the other waste reductions tools include zero defects, setup reduction and line balancing. The goal of zero defects is to ensure that products are fault-free all the way, through continuous improvement of the manufacturing process (Karlsson et al. 1996). Human beings almost invariably will make errors. When errors are made and are not caught then defective parts will appear at the end of the process. However, if errors can be prevented before they happen then defective parts can be avoided. One of the tools that the zero-defect principle uses is poka-yoke

Poka-yoke, which was developed by Shingo, is an autonomous defect control system that is put on a machine that inspect all parts to make sure that there are zero defects. The goal of poka-yoke is to observe the defective parts at the source, detect the cause of the defect, and to avoid moving the defective part to the next workstation (Feld 2000). Ohno at Toyota developed SMED in 1950. Ohno's idea was to develop a system that could exchange dies in a more speedy way. By the late 1950's Ohno was able to reduce the time that was required to change dies from a day to three minutes (Womack et al. 1990). The basic idea of SMED is to reduce the set up time on a machine.

There are two types of setups: external and internal. Internal setup activities are those that can be carried out only while the machine is stopped while external setup activities as possible from internal to external (Feld 2000). After all activities are identified then the next step is to try to simplify these activities (e.g., standardize setup, use fewer bolts). By reducing the setup time many benefits can be realized. First, die-change specialists are not needed. Inventory can be reduced by producing small batches and more variety of product mix can be run.

Line balancing is considered a great weapon against waste, especially the wasted time of workers. The idea is to make every workstation produce the right volume of work that is sent to upstream workstations without any stoppage (Mid-American Manufacturing Technology Center press release 2000). This will guarantee that each workstation is working in a synchronized manner, neither faster nor slower than other workstations.

2.6.2.10 From Lean Manufacturing to Lean Enterprise

The elimination of waste is a process that examines the system as a whole. The big picture is to look at the interdependent segments of the company starting from raw materials to distribution and sales of finished goods. Womack and Jones define the lean enterprise as "a group of individuals, functions and legally separate but operationally synchronized companies" (Womack & Jones 1994). By managing the whole system the focus is to manage the value adding activities holistically and not as a sum of separate parts (Dimancescu, Hines & Rich 1997).

To accomplish this, companies and managers should put more efforts to elevate the whole enterprise as opposed to focusing on the performance of persons, functions, and parts of the company. Lean enterprise is an extension of lean manufacturing. However, lean enterprise goes further by concentrating on the firm, its employees, its partners and its suppliers, to bring value to the customer from his or her perspective.

The lean enterprise tries to line up and coordinate the value creating process for a finished product or service along the value stream. It tries to thoroughly examine all the steps that are needed to bring a new product or service from idea to production, from order to delivery, and from raw material to final delivered product. All processes are continually examined against the customer's definition of value, and non-value added activities and waste are forcefully and methodically eliminated.

There are three different types of activities that exist in almost all organization (Monden 1998):

- 1) Value adding activities: These include all the activities that the customer envisions as valuable, either in a product or a service. Example includes converting iron ore into cars, forging raw material and painting a car body. To define a value activity, a service or product a customer would be willing to pay for the activity.
- 2) Necessary non-value adding activities: There are activities that in the eye of the final customer do not make a product or service more valuable but necessary under the current operating conditions. Such waste is difficult to remove immediately and should be targeted for longer-term change. Examples include walking long distances to pick up a part or unpacking vendor boxes. These can be removed by changing the current layout of a line or organizing vendor items to be delivered unpacked.

- 3) Unnecessary non-value adding activities: These include all the activities that the customer envisions as not valuable either in a product or as a services and are also necessary under the current circumstances. These activities are pure waste and should be targeted for immediate removal. Example include waiting time, stacking of products and double transfers.

There are as lot of companies that are implementing lean manufacturing. However, many of these are still coping with mastering the idea due to lack of understanding of its core concepts. So it might seem that when companies are still not capable of lean manufacturing they should not even look ahead to a lean enterprise. Womack and Jones argue this point by noting that in order for any one member of the supply chain to keep up the moment, it is important for all parts of the chain to pull together. This means that if one member becomes lean other members of the value stream will not share the benefits unless they all participated in the process (Womack et al. 1994).

2.7 Value steam mapping

A value stream is a collection of all activities of all actions value added as well as non-value added that are required to bring a product or a group of products that use the same resources through the main flows, from raw material to the arms of the customer (Rother & Shook 1999). These actions are those in the overall supply chain including both information and operational flow, which are the core of any successful lean operation. Value steam mapping is an enterprise improvement tool to assist in visualizing the entire production process, representing both material and information flow.

The goal is to identify all types of waste in the value stream and to take steps to try and eliminate them (Rother & Shook 1999). Taking the value stream viewpoint means working on the big picture and not individual processes, and improving the whole flow and not just optimizing the piece. It creates a common language for production process, thus facilitating more thoughtful decisions to improve the value stream (McDonald, Van Aken & Rentes 2002). While researchers and practitioners have developed a number of tools to investigate individual firms and supply chain, most of these tools fall short in linking and visualizing the nature of the material and information flow in an individual company.

Lately, and in particular over the last few years a number of companies have utilized value stream mapping. The application crosses over different types of industries and organizations such as automotive, aerospace, steel, and even non-manufacturing industries including information technology. One application of value stream mapping was found in steel manufacturing. A current state map was created for a steel producer, a steel service center and a first-tier component supplier (Brunt 2000). The map shows the activities from hot rolling through delivery to the vehicle assembler. The overall goal of the study was to improve the supply chain performance lead-time.

The current state map identified huge piles of inventory and long lead-time. A future state map was developed. On the future state map target area were subjected to different lean tools including kanban, continuous flow and EDI. The results obtained by implementing the future state map were reduction in lead-time from between 47 and 65 days to 11.5 days, and a reduction of cycle time from 7262 sec to 6902 sec (Brunt 2000).

Another application of value stream mapping is the aircraft manufacturing (Abbett & Payne 1999). Current and future state maps were developed with the objective of reducing lead-time according to customer requirements. The implementation of the future map attained lead-time reduction from 64 to 55 days. Lean tools such as kanban and continuous flow were utilized to help achieving this reduction. An application of value stream mapping was also found in the distribution industry (Hines, Rich & Esian 1998).

Partasco a distributor of electronic, electrical and mechanical component decided to map the activities between the firm and its suppliers. Partasco introduced EDI which allowed the firm to work with its suppliers effectively and more quickly. In short time period the company was able to reduce the lead-time from 8 to 7 days.

At the level of individual firm many organizations have moved toward becoming lean by adapting different lean tools such as JIT, setup reduction, 5s, TPM, etc. In many of these cases firms have reported some benefits; however, it was apparent that there was a need to understand the entire system in order to gain maximum benefits. For example, Gelman Science, Inc., a manufacturer of micro porous membrane filtration products started their lean journey by implementing setup reduction. Some reductions were realized, but throughput stayed the same. So in order to attain noteworthy improvements they decided to use value stream mapping to visualize the entire flow and select lean tools that yielded maximum benefits (Zayko, Broughman & Hancock 1997).

2.8 Review of literature related to kaizen concept

The philosophy of Kaizen has kindled considerable interest among researchers because it increases productivity of the company and helps to produce high-quality products with minimum efforts. Several authors have discussed the concept of kaizen including (Deniels 1996; Reid 2006) etc.

According to (Imai 1986), Kaizen is a continuous improvement process involving everyone, managers and workers alike. Broadly defined, Kaizen is a strategy to include concepts, systems and tools within the bigger picture of leadership involving and people culture, all driven by the customer.

Watson (1986) says that the origin of Plan-Do-Check-Act (PDCA) cycle or Deming cycle can be traced back to the eminent statistics expert Shewart in the 1920s. Shewart introduced the concept of PDCA. The Total Quality Management (TQM) guru Deming modified the Shewart cycle as: Plan, Do, Study and Act. The Deming cycle is a continuous quality improvement model consisting of a logical sequence of these four repetitive steps for Continuous Improvement (CI) and learning.

The PDCA cycle is also known as Deming Cycle, the Deming wheel of CI spiral. In 'Plan phase', the objective is to plan for change predict the results. In 'do phase', the plan is executed by taking small steps in controlled circumstances. In 'study/check phase' the results are studied. Finally in 'act phase', the organization takes action to improve the process.

(Suzaki 1987) explains that CI or Kaizen is a philosophy widely practiced in manufacturing and quality circles. As the name implies, it relies on the idea that there is no end to make a process better. Each incremental improvement consists of many phases of development. Originally used for enhancing manufacturing processes, the philosophy has gained considerable popularity recently, and has been extended to all aspects of business including the software industry.

(Wickens 1990) describes the contribution of teamwork to make the concept of Kaizen. The key role and authority of each supervisor as a leader of his team has been described by taking an example of Nissan Motor Plant in the UK. Emphasis is placed on teamwork, flexibility and quality. Teamwork and commitment do not come from involving the representatives of employees, but from direct contact and communication between the individual and his boss.

(Teian 1992) describes that Kaizen is more than just a means of improvement because it represent the daily struggles occurring in the workplace and the manner in which these struggles are overcome. Kaizen can be applied to any area in need of improvement. (Hammer et al. 1993) explain that Kaizen generates process-oriented thinking since processes must be improved before better results are obtained.

Kaizen signifies small improvements that have been made in the status quo as a result of ongoing efforts. On the other hand innovation involves a step—improvements in the status quo as a result of large investments in new technology and equipments or a radical change in process design using Business Process Re-engineering (BPR) concept.

(Bassant & Caffyn 1994) define the CI concept as 'an organization-wide process of focused and sustained incremental innovation'. Many tools and techniques are developed to support these processes of incremental innovation. The difficulty is the consistent application of CI philosophy and CI tools and techniques. As an organizationwide process, CI requires the efforts of all employees at every level.

(Deming 1995) highlights that organizations are evolved at a greater rate than at any time in recorded history. Since organizations are dynamic entities and since they reside in an ever-changing environment, most of them are in a constant state of flux. This highly competitive and constantly changing environment offers significant managerial opportunities as well as challenges. To effectively address this situation, many managers have embraced the management philosophy of Kaizen.

(Deniels 1995) explains that the way to achieve fundamental improvement on the shop floor is to enable operators to establish their own measures, to align business strategies and to use them to drive their Kaizen activities. The author explains that operators are the experts and once they realize that they are the ones who are going to solve their problems, and then all they need is some direction. He also discusses the role of performance measurement in fashioning the world class manufacturing company.

(Yeo et al. 1995) describe the viewpoints of various traditional quality management gurus on the concept of 'zero defects' and 'do it better each time' that these strategies are the important ways to improve quality continuously. 'Zero defects' represents CI over quality by detection of defects. A phrase 'do it better each time' (DIBET) strategy is associated with constant, conscious and committed efforts to reduce process variation. They conclude that CI is the most important way to manage business through these strategies.

(Newitt 1996) has given a new insight into the old thinking. The author has suggested the key factors to determine the business process management requirements. The author also has stated that Kaizen philosophy in the business process management will liberate the thinking of both management and employees at all levels and will provide the climate in which creativity and value addition can flourish.

(Womack & Jones 1996) refer to Kaizen as a lean thinking and lay out a systematic approach to help organizations systematically to reduce waste. They describe waste as any human activity that absorbs resources but creates or adds no value to the process. Most employees could identify several different types of muda in their workplace.

The authors state that until these employees have been taught the essentials of lean thinking, they are unable to perceive the waste actually present in their environment. They provide an example involving preparing a newsletter for mailing. Most of us would tackle the problem after the printing has been completed by folding all copies of the newsletter, placing stamps on the envelopes, then inserting the folded newsletter into an envelope and finally, sealing all the envelopes.

When examining this process, it is not readily apparent to the observer that the newsletter is picked up four times. We compartmentalize and attempt to group tasks without looking at the flow. It would reduce muda (waste) if newsletter has been folded, inserted into the envelope, stamped as stacked. When explained, this opens up a new world of operation to those studying manufacturing processes. The process of Kaizen carries many other benefits as well.

(Ghalayini et al. 1997) describe that Kaizen is characterized by operatives on the shop floor, identifying problems and proposing solutions—the epitome of spontaneous, bottom-up change. Small scale tuning of a system, by its very nature, is likely to lower the cost, generated from an intimate knowledge of a small part of the system. Progress is likely to be largely outside the control of management who are not the sponsors of change but only play, at most, a supporting role. Even though the aggregate effects may be significant, there is an obvious danger that the process may be erratic and fragmented.

(Imai 1997) describes that the improvement can be divided into Kaizen and innovation. Kaizen signifies small improvements as a result of ongoing efforts. Innovation involves a drastic improvement as a result of large investment of resources in new technology or equipment. The author also explains that in the context of Kaizen, management has two major functions: maintenance and improvement. Maintenance refers to activities directed towards maintaining current technologies, managerial and operating standards, and upholding such standards through training and discipline.

(Williamson 1997) highlights the target costing and Kaizen costing concept, one of the manufacturing techniques, which has been developed in Japan. Target costing is a process, ensuring that the products are designed in such a way that the company can sell them cheaply and still make a fair profit. Kaizen costing focuses on the value and profitability of the manufacturing phase, both of new and existing products.

Kaizen costing activities should be a part of a process of business improvement continuously, with improvements in quality, product functionality and service jointly. Kaizen activities and targets may vary depending on the type of cost. Combining target costing and Kaizen costing provides a basis of the total life-cost management, managing cost throughout the product life cycle.

(Cheser 1998) explains that Kaizen is based on making small changes on a regular basis—reducing waste and continuously improving productivity, safety, and effectiveness. While Kaizen has historically been applied to manufacturing settings, it is now commonly applied to service business processes as well. (Kim & Mauborgne 1999) call incremental improvement as 'imitation' and not 'innovation'. According to them, companies should focus on a proactive strategy, which focuses on the creation of new customers as well as sustaining existing customers.

They refer this strategy as 'value innovation strategy' where the emphasis is on value and customers and to a lesser extent on the competition. The focus on value innovation pushes managers to go beyond continuous incremental improvements of existing products, service, and processes to new ways of doing things.

(Williams 2001) highlights that CI techniques are the recognized way of making significant reduction to production costs. Quality Function Deployment (QFD) is a well-known technique for translating customer requirements for a product into functional specification. Data suggests that the best opportunity for significant reduction in the overall cost of manufacturing a product is at the design stage of the new product development program.

(Doolen et al. 2003) describe the variables that are used to measure the impact of Kaizen activities on human resource. These variables include attitude toward Kaizen events, skills gained from event participation, understanding the need for Kaizen, impact of these events on employee, impact of these events on the work area, and the overall impression of the relative successfulness of these events.

(Chen & Wu 2004) explain that CI can be generated and sustained through the promotion of good improvement model and management support. In fact, it is not easy in reality. The improvement case may fail without carefully examining the problem in the activity.

(Hyland et al. 2004) highlight the major potential benefits of CI. These benefits are: increased business performance (in terms of reduced waste, setup time, breakdowns, and lead time) and increased 'people performance' in the form of improved development, empowerment, participation, and quality of work life of employees; all of which address contemporary societal needs.

(Abdolshah & Jahan 2006) describe how to use CI tools in different life periods of the organization. Organizations are facing the problem of which CI tool should be used during different stages and life periods of organization. Methodologies of applying both quantitative and qualitative tools in different life periods of an organization have been discussed.

2.9 Review of literature related to case studies

The case studies are the important means to check the effectiveness of Kaizen philosophy in different fields of applications, especially in manufacturing industries.

Many researchers have performed case studies to cover wide range of benefits like increased productivity, improved quality, reduced cost, improved safety and faster deliveries, etc. (Powel 1999).

(Jayaraman et al. 1995) demonstrate the application of the CI in simulation model development. This study presents several techniques that can be used to build accurate and efficient model of systems that include one or more transfer machines and long conveyors. The system under study shows a fair amount of complexity, so a five staged model has been developed to obtain a balance between model accuracy and execution performance. The simulation analysis helps to predict optimal combinations of operation times, material handling speeds, buffer sizes, preventive maintenance, breakdown schedules; and a considerable cost saving has been obtained.

(Radharamanan et al. 1996) apply Kaizen technique to a small-sized custom-made furniture industry. The various problems that have been identified through brainstorming process are absence of appropriate methodology to assure quality, less compatibility of the individual protection equipment, old machines, disorganized workplace, inadequate and insufficient number of measuring instruments, lack of training, insufficient illumination at certain places and poor quality of raw material. Suggestions are also given to solve these problems.

The main aim is to develop the product with higher quality, lower cost and higher productivity to meet customer requirements. (Chaudhari 1997) describes the key factors of the CI system at Morris Electronics Limited, an Indo-Japanese joint venture firm that has contributed to dramatic improvement in the productivity and sustained competitiveness.

(Bond 1999) has studied the Kaizen and re-engineering programs in a leading international company manufacturing surgical products. Research data is collected from a program of semi-structured interviews with appropriate staff at all levels ranging from senior management to machine operators. Key performance factors that are identified include quality, delivery reliability, customer satisfaction, cost, safety and morale. Result shows that performance measures

(Savolainen 1999) has conducted two case studies including a medium sized metal industry and other larger group in the construction and concrete industry. The main aim of the studies is to increase the understanding of the processes and dynamics of CI implementation. The focus is placed on how these companies are renewed through the embedding of quality related management ideology. The paper has discussed the processes and dynamics of CI implementation conceptually and empirically. The results show that the dynamics of CI implementation process is cyclic in nature, which progresses at different speeds and with varying intensity.

(Burns 2000) describes the importance of two techniques namely Overall Equipment Effectiveness (OEE) and set up reduction, taking an example of Weston EU Company. No appropriate measures of the process and equipment usage are available. Initially, six pilot areas have been identified, out of these three turned out to be successful. OEE is actually used to drive CI in the development of a company. Setup reduction has been applied to reduce change over times, to meet the customer demand for greater product mix and to overcome the difficulties in machine loading. Both techniques are described in terms of how they help the company to drive improvement in the core of business-70 capital equipment CNC machines.

(Chen et al. 2000) apply Kaizen approach on a small manufacturing designing system. The focus of this project is the virtual manufacture of meat tenderizer. The product is currently too expensive to produce. In order to address this system design problem, a design engineer, a manufacturing engineer, a quality engineer and two machining operators are invited to be the team members in this Kaizen project.

After identifying the problem, a brainstorming process has been used to explore the team goals by receiving the information on current process of the product. Cellular manufacturing system is introduced to reduce production costs. Kaizen brings CI, it reduces 25% of the unit cost, reduces floor space requirement by 15% and it also develops a better communication network throughout the organization.

(Lee 2000) has conducted a case study at Nichols Foods manufacturing food products. There was a lack of standard operating procedures, forces and structure. The study describes how the company values have improved the work environment for the employees and motivated them to achieve excellence. The paper describes that how the Kaizen program has been implemented in this company using 5S technique and team training. The result shows decrease in quality rejections, reduction in change over times and increase in manufacturing efficiencies.

(Lee et al. 2000) describe that inclusion of the Kaizen approach in industrial technology is beneficial. This case study provides a description of the steps used to implement lean thinking in a typical mid-western company developing a dynamic Tri-Resin fiberglass rod, which has 100 times more tensile strength than that of steel. After implementing lean thinking, reduction in space used in the building, material handling costs and also lower scrap rates can be expected.

(Ashmore 2001) discovers that Kaizen is a hardheaded weapon in hard-pressed manufacturing industries. Kaizen technique has been applied to Toyota in response to increasing competition and costs. It has found that after implementation of this technique, the sale is increased by multiple of not less than 69% and its profit by 54 times in an economic year. The author has also discussed the role of SS by eliminating waste and JIT in making CI.

(Palmer 2001) has focused his study on the 'inventory management Kaizen' that has been conducted at 'BAE SYSTEM' to remove the muda (waste) from the receiving and storing process. Kaizen event encompasses about five months one week from actual analysis of the process and the remainder working to implement the changes that are identified. Results show that the process time is reduced from 610 hours to 290 hours. Ultimately the Kaizen event results in saving well over million dollars per year.

(Ahmed et al. 2005) conduct a study in a casting based manufacturing plant, which is currently implementing Kaizen to achieve higher productivity. The study has focused on the Performance Indicators (PIs) currently being measured by the company. Careful investigations and observations have been taken to show the effectiveness and efficiency of the implementation of the Kaizen system in an innovative manner. After analyzing the collected data, sufficient information has been generated on various aspects of performance evaluation. However, due to lack of financial data, monetary-based PIs could not be carried out in this study.

(Granja et al. 2005) study the target and Kaizen costing concept in a construction company. The aim is to develop the framework taking together these two matching approaches, which provides a basis for a total cost management system. The authors explain that the continuing series of Kaizen activities are needed to achieve product performance and reduce the cost. Combining target and Kaizen costing is a powerful approach for the construction company by assuring value for the customer at a low but profitable price.

(Dehghan et al. 2006) describe the case study of Kaizen project that is performed by National Productivity Improvement Program (NPIP), at Chaharmahal-Bakhtiari Agriculture Organization. Two Kaizen methodologies namely 5S and process improvement are used for this CI project. The status of the process before and after Kaizen is shown by using flow charts, block diagrams and spaghetti charts, etc.

Shortening of work processes and decrease in financial expenses result in increasing the satisfaction level of both domestic and foreign customers. Results show the decrease in 11% stations, decrease in 11.7% moving around, 16% time saving, 34.2% length decrease and 53% saving in transportation cost.

(Vaidya & McCartney 2006) explain the application of Kaizen to welding operations by taking two examples of a small sample of over 100 welding performance appraisals that has been carried out in Canada in recent years. To control semiautomatic welding processes, 27 different parameters have to be controlled to ensure quality of the weld. The authors suggest that Kaizen should be applied to three welding parameters including wire feed speed, welding technique and welding speed, as a start. He also explains that it requires the involvement of everyone in the organization. By following these rules, spectacular results can be produced.

(Kikuchi et al. 2007) aim at applying OEE method to cost reduction by using Kaizen technique to a semiconductor industry. The consumption of gases and chemicals for a specific process is very high. Two different methods of Overall Consumable Effectiveness (OCE) technique are adopted to reduce the consumption of gases and chemicals for 12-items. The result indicates a cost reduction of 7% annually for the use of gases and chemicals. This experience has raised the awareness that the Kaizen process can be applied to other areas also.

(Chandrasekaran et al. 2008) apply Kaizen technique to solve the 'part mismatch problem' in automobile assembly production line. Step-by-step Kaizen procedure has been followed to solve the problem by data collection, root cause analysis, selection of the best solution method, corrective action and documentation. The various benefits that have been observed after implementing Kaizen include elimination of major functional problem, reduction in quality rejections, elimination of rework processes and a considerable cost saving.

2.10 Reviews of literature related to surveys

Surveys are the effective means to check the performance of different Kaizen practices, determining the extent of use of these practices and to check how the industries are deploying various Kaizen practices to achieve their goals.

(Gibb & Davies 1990) have identified and highlighted the success factor for CI or Kaizen and innovative strategy in Australian Small to Medium Enterprises (SMEs), the importance of market orientation and effective strategic formulation in successful SMEs. The critical success factors that have been highlighted in the survey include promoting a corporate culture, creating an effective structure, analyzing competitors, developing cooperation and partnerships, and developing flexibility and speed of response.

(Soderquist 1996) investigate CI and innovation practices in French SMEs. In this survey, they examine the drivers for change and the short- and long-term goals, the sources of innovation and the nature of innovative management in French SMEs. The respondents are asked to consider a recent and successful innovation of a product and then to indicate just how important the number of items used as a source of particular innovation.

The top nine sources of innovation that have been found are introduction of the new product, CI of work processes, radical change, increased focus in marketing/sales efforts, reduction of indirect staff numbers, improvement of staff competence, improvement of the quality of product and services, improvement of the quality of management, and efforts to improve supplier performance. The survey identifies two groups of SMEs.

The first group has reported satisfaction with their organization's performance in product innovation and has also reported that their organizations have a strategic approach to innovation. The second group comprises SMEs, which are satisfied with the current actions for improving short-term performances. Further analysis shows that the second group is more likely to report a stronger emphasis on performance management approach.

Based on the survey in a small-scale manufacturing company, (Irane & Sharp 1997) suggest that CI strategy should be ingrained as a belief into the employees' heart. The ideal situation of CI strategy is its integration with the corporate culture. (Basant 2000) presents a survey that has been conducted by CI Research Advantage (CIRCA) at UK firms.

The survey suggests that 65% of companies consider CI to be important strategically, around 50% have instituted some form of systematic program to apply these concepts, 19% claim to have a widespread and sustained process of CI in operation, and of those firms using CI, 89% claims that it has an impact on productivity, quality, delivery performance or combination of these.

(Hongming et al. 2000) carry out a survey in Chinese companies and find that not all companies that have carried out CI activities achieve desired results. It has significant impact on companies, where CI implementation requires adequate input on company capital human resource and organizational activities. In the organizational structure, it is a challenge for companies' business principles and operations methods.

(Mackle 2000) presents a survey conducted by a Kaizen institute that has been designing and implementing various CI programs in most of the companies in UK. The institution has conducted a survey with all of its UK clients. Outcomes of the survey show that organizations have not successfully implemented these improvement programs. The opportunities for improvement are also identified in this survey.

(Terziovski 2001) presents the result of a mail survey used to investigate the relationship between CI and innovation practices and SME performance in 115 Australian manufacturing industries. A total of 19 questions have been included in the questionnaire. 57 independent variables and 12 dependent variables are analyzed using multiple regression analysis. The author concludes that CI innovation management strategy and system are significant predictors of SME performance.

(Gonsalves 2002) performs a survey on the effect of ERP and CI on the performance in 500 manufacturing companies. He concludes that CI implementation has positive influence on BPR execution. Integrated CI and BPR have positive effects on the company's performance.

(Malik & YeZhuang 2006) perform a survey in 105 Spanish and 50 Pakistani companies to analyze the outcome of CI practices carried out in these industries. The questionnaire is circulated to different industries. Twelve CI tools have been investigated. The result shows that the Spanish industries utilize these tools more than Pakistani industries. The Spanish industries are comparatively more experienced and advanced than Pakistani industries.

(Tseng et al. 2006) investigate the effects of CI and cleaner production on operational performance. A total of 223 responses have been obtained after distribution of the questionnaire. A sample has been collected via a survey of Taiwan electronic manufacturing firms. The direct and indirect influences of independent variables on dependent variables are tested by Structural Equation Modeling (SEM) technique. The result shows that the CI might not be able to directly improve the operational performance. However, CI plays a significant role in cleaner production implementation.

(Yan-jiang et al. 2006) conduct a survey by using the data of global continuous innovation network to analyze the influencing factors of CI. This survey designs 18 questions to describe the reasons why companies are implementing CI activities, 13 questions to describe the company's external environment and 11 questions to describe the situation of CI activities in functional departments of the companies. The result shows that the internal motivation factors are responsible for popularization of CI activities and have varying degree of influence on these activities.

(Malik et al. 2007) conduct a survey by a comparative analysis between two Asian developing countries, China and Pakistan, by investigating how they are deploying CI practices. The questionnaire consists of 18 selected blocks of questions related to organization and its operation of CI, supporting tools used in the improvement activities, effects of improvement activities and company background and its characteristics. The result shows that the industries in both of the countries are deploying CI methodologies, but with different proportions.



2.11 Summary

It is clear and evident that lean manufacturing tools like manufacturing kaizen are powerful concepts that when adopted can create superior financial and operational results. The preceding literature review suggests that JIT and kanban approaches have been applied at some process facilities and good results have been reported. On the other hand the literature suggests that nobody has systematically examined the use of lean manufacturing tools and techniques at the process facility, such as APSA (Pty) Ltd. Also, the literatures suggest that process mapping is a good startup tool for companies that want to become lean. Process mapping can be effectively used to unveil wastes in the value stream.

In order to adapt lean manufacturing tools to the process industry, one needs to thoroughly examine different characteristics of the same and develop a systematic approach to best utilize these techniques at the process facility. The manufacturing kaizen conclusions should not be doubted in any manner because the success rate of manufacturing kaizen applications has been extremely high. All over the world, there have been companies which have used manufacturing kaizen principles and profited significantly, as discussed in the literature.

The names that could be mentioned are Toyota and Honda which are the two big names of automotive company. Other companies are Fidelity investments, Johnson and Johnson and Canon. All these companies openly confess that the fame they are enjoying today is because they applied the principles of manufacturing kaizen and did not lose faith in it. While some companies continue to grow based on economic constancy, other companies struggle because of their lack of understanding of the change in customer mind-sets and cost practices. To get out of this situation and to become more profitable, many manufactures have started to turn to lean manufacturing principles to elevate the performance of their firms.

The basic ideas behind the lean manufacturing system, which have been practiced for many years in Japan, are waste elimination, cost reduction and employee empowerment. In this research, manufacturing kaizen was the tool used to address these. The lean manufacturing discipline is to work in every facet of the value stream by eliminating waste in order to reduce cost, generate capital, bring in more sales, and remain competitive in growing the global market. So the resounding principle of lean manufacturing is to reduce cost through continuous improvement that will eventually reduce the cost of services and products, thus growing more profit.

“Kaizen” focuses on abolishing or reducing wastes and on maximizing or fully utilizing activities that add value from the customer’s perspective. There is no doubt that the elimination of waste is an essential ingredient for survival in today’s manufacturing world. Companies must strive to create high-quality, and low cost products that can get to the customers in the shortest time possible. This was also mentioned in the literature review. Chapter 3 outlines the research methodology. The researcher will show how data is been collected, interpreted and analyzed.

The manufacturing kaizen approach provided here is inclusive, in that it encourages all stakeholders in every position within the organization to take a critical look at, and identify anything that needs elimination or improvement. This will require responsive leadership, and the creative and innovative participation of each organizational member.

A company can move closer to perfection by continuously working on improving its current production system by using manufacturing kaizen events or workshops. Manufacturing kaizen is the Japanese idea that “great improvement eventually comes from a series of small incremental gains” (Nicholas 1998). This is the purpose of performing a manufacturing kaizen. The goal is to improve the production process by holding workshops where employees “try to accomplish as much actual manufacturing kaizen as possible” (Shook 1998). The team has seen the great results and improvements during this practical research.

Waste consumes resources pointlessly (Womack, Jones & Ross 1990). These resources are predominantly human and material in nature. People implementing wasteful processes do not add value in a business. They are robbed of the satisfaction of engaging in meaningful tasks that produce outputs that are well received and well rewarded by their customers. Moreover, they are degraded as humans because engaging in activities that are not meaningful treats their energies and earnest efforts as commodities of little value.

When constrained to execute processes that are not adding value without the opportunity to improve them, people are denied capacity to learn and improve and thereby grow to the full measure of their capabilities. With regard to material resources, the financial and material investments in enterprise are hampered from achieving the greatest returns possible.

Application of manufacturing kaizen to the continuous process industry has been distant and not much has been written about it. The argument has been that such industries use different approaches/methods to improve their manufacturing processes. Some companies have also been hesitant to adopt the manufacturing kaizen as a tool because they say the tool cannot match high volume and long setup times processes. While it seems that some lean manufacturing tools especially manufacturing kaizen are difficult to be applied in the process industry, other are not, for example, (Cook & Rogowski 1996) used just-in-time concept at a process facility, and both have reported good results.

Other related tools like Total Productive Manufacturing (TPM) which embodies some lean principles have been used by some multinational companies in South Africa to improve processes. TPM addresses the concept that productivity can be improved if workers perform daily inspections, lubrication, parts replacement, repair, troubleshooting, accuracy checks and so forth on his/her own equipment.

The aim is achieving that goal of “keeping one’s own equipment in good condition by oneself” so that machines are kept in good operational shape for production to take place. It addresses planned maintenance as well as autonomous maintenance that determine the maintenance requirement of machines in its operating context. In fact, most western companies are moving towards TPM implementation, (Willmott 1994), but like any other manufacturing system, it will not be always perfect. That is why some companies are failing to implement it and indeed some of the lean related processes.

The basic ideas behind the manufacturing kaizen system, which have been practiced for many years in Japan, are waste elimination, cost reduction and employee empowerment. The Japanese philosophy of doing business is totally different than the philosophy that has been long prevalent in most western countries. The traditional beliefs in the west had been that the only way to make profit is to add it to the manufacturing cost to come up with a desired selling price, (Cooper & Schindler 1998).



2.12 Conclusion

From the literature, it can be concluded that there is a reasonably vast literature available on Kaizen philosophy, which gives a broad view of past practices and researches carried across the globe. Although as Kaizen is a widely accepted philosophy in manufacturing industries, more research work is required in this field. The authors feel that Kaizen philosophy can also be applied to different areas like business, service, commerce, etc. So a great scope of research is available for new researchers in this field.

Success stories reveal that it requires team efforts involving every employee in the organization to fully implement the system. However, awareness among employees regarding different strategies that are involved in Kaizen philosophy, various principles behind these strategies and the use of these strategies in different circumstances plays an important role. So more research is required which could improve the awareness aspects, as these factors are highly important for the success of the Kaizen philosophy in most of the manufacturing industries across the globe.

The next discusses a variety of research approaches used by the researchers in data collection and analysis. The chapter also outlines the research approached used to achieve the goal of the research. The chapter shows how the work process will be analyzed and the how waste will be identified in the work process. The goal was to ultimately reduce the indentified waste in the process using manufacturing kaizen.

CHAPTER 3

3. Research methodology

3.1 Introduction

In the previous chapter the literature review was presented. Various concepts that formed part of the research topic were discussed. The theory presented was critically reviewed. Chapter 3 discusses various research approaches used by researchers in conducting research. The uses of qualitative and quantitative approaches were then argued. The chapter also describes the research approach used to achieve the goal of the research. The research methodology highlighted how the work process was analyzed. The methodology also described how waste was identified in the work process. The goal was to ultimately reduce the identified waste in the process. Manufacturing kaizen was the tool used to analyze the process. The tool was also used to eliminate the identified waste in the process.

The research was carried out in a company called APSAP. The company could not meet high demand of gas cylinders for key industries resulting in a need to improve the cycle time and cylinder preparation process. The methodology outlines the approach used for data collection. The researcher conducted direct observations. Data collection was done over a period of a week and firm conclusions were made.

According to (Cooper & Schindler 1998) there are only two alternatives that can be used to gather data and that is by observing conditions, behaviour, events people and processes and to communicate with people about various topics. The other one is by a personal interview (i.e. face to face) in a two-way conversation initiated by an interviewer to obtain information from a respondent. According to these two authors, observation is one of a few options available for studying records and recording data. In this research, data was collected by observations of processes and communicating to people.

The researcher also tapped from his previous experience as a certified manufacturing kaizen practitioner, see attached certificate in appendix F. The researcher felt that an appropriate way to achieve these objectives was to obtain quality primary data from leading role players in the company mainly the workers who formed the backbone of this research. The research approach helped in addressing the goal of the company. The approach also outlines the analysis of data. The goal was to eventual reduce waste in the cylinder preparation area.

The primary objective was to study and analyze the cylinder preparation process in APSAP PTY LTD. The secondary objective was to identify waste in the process. The researcher carried out direct observation as he was physically present and personally monitored what was taking place.

Production personnel were key aspect in implementing the manufacturing kaizen event. It was crucial to identifying key people that were to be used in manufacturing kaizen exercise. It was essential that data was collected from the correct subject matter experts who were part of the manufacturing kaizen process. The production personnel assisted in collecting precise information since they knew and are the owners of these processes.

3.2 Data Collection

Data collection was conducted by using the five steps applicable to manufacturing kaizen. The initial step entailed capturing of the process map, which was then used to review targeted work process information. The standard operating procedure (SOP) was never put in place before. The process map was then eventually used to create the operating procedure with standard times to measure improvements that can be achieved. This information was, in turn, applied in analyzing the process.

The second step involved conducting a walk-through the target work process, where sources of waste were identified. The types of waste the research team elected to focus on were those that contributed significantly to cycle times of the process.

In this respect, the following questions permitted collection of raw data: (1) how many observations would be made of the target work process; (2) what operations would be observed; (3) which operators would be involved; (4) in what order would it occur; (5) who would perform each role (e.g., process observer, timekeeper, distance measurer, etc.) during the observations.

A draft plan was prepared to expedite the work involved and to ensure reliability of information acquired. Variability from reports on cycle times required to complete the preparation work process were recorded accordingly. The research required observation of multiple cycles, which involved monitoring the processing of multiple orders. In this instance, the approach included only two observations of the cylinder preparation work process, as this seemed to show a consistent estimate of cycle times. In addition, these observations were carried out during the day shift.

In terms of the observations, the focus was placed on actual operations performed by employees as opposed to those performed by machines. To facilitate this process, an operator was identified for cylinder preparation, whilst a supervisor was selected to conduct the process observation, on account of experience.

The supervisor recorded and described each work activity executed by the operator using the waste observation form. The researcher performed the utility role, which included collection of sample documentation received or produced by employees as a part of their job function.

One team member was elected to assume the role of documenter and was responsible for electronically recording all collected information. In addition, a timekeeper reported the end time for each work activity using a stopwatch. The cycle time of each work activity was also computed.

A distance measurer documented the distance moved by an operator while executing a job by means of a distance wheel. During the observations, the process observer would call for time and distance measures and these were recorded on the process observations data sheet along with the identity of each work activity.

A spaghetti chart plotted the movements of the operator during travelling and searching. The observations of the cylinder preparation process continued over a period of five hours a day. This enabled verification of the activities and allowed for certain activities to be repeated for confirmatory purposes.

The third step involved development of a mission statement, which plainly clarified the business problem. The fourth step entailed cultivating a goal statement, which consisted of dual components, namely a “what” that described the state of waste to be reduced and a “how much” that demarcated the particular amount of waste reduction. Furthermore, to enable specific focus to be placed on the scope of the event, defining the “do’s” and the “don’ts” were considered a final important step.

3.2.1 Review target work process information

The primary objective of the thesis was to study and analyze the cylinder preparation process in APSAP PTY LTD. A description of the target work process was captured through a process map. The process map collected all the activities valued added as well as non-value added required in preparing cylinders. Process mapping is an improvement tool to assist in visualizing the process. The first step was to choose a work process as the target for improvement. The goal was to identify all the types of waste in the process and eliminate them.

The researcher mapped the process using a pencil and paper. There were a lot of benefits in drawing the map by hand with paper and pencil. Manual mapping helped showing what was happening in the cylinder preparation section. Also, the process of doing corrections was easy. The map was then redrawn using microsoft visio, shown in appendix A. The map was drawn while walking along the actual process. At each step all the critical information including lead-time, cycle time, changeover time, stoppage time were documented.

The typical times it took to complete each task was documented. Work activities related to each other and any documents which the performer of the task receives as inputs or produces as outputs were listed. Additional descriptive information about each task was gathered and the location within the workplace where the task is performed was identified. The researcher also identified the contact person for each task, a performer from whom one may obtain added information about the task.

Verification on the accuracy of the completed or modified work process description was done. Team members familiar with the target work process were to check the completed product. Confirmation that the work process as mapped was the official approved methods of work was then requested. The corrections the team offered into the final description were then incorporated. The second step was to perform the walkthrough of the target work process.

3.2.2 Walk through the target work process.

The team was prepared to complete the walk through. The researcher explained what a walk through was and why it was done. The purpose of the walk through was to gather more information about the work process, the work areas within which it is performed, and any instances of waste. The team had the facts needed to define a mission and set goals for the event.

Team members literally walked through the process from beginning to end. The team was, focusing on learning about the work process and detecting instances of waste. The team made observations, asked questions, and listens to what workers said. After the walk through, the kaizen event co-leader or researcher asked for inputs from each operator to gather ideas about ways to improve the process

In planning the walk through, the researcher saw that the team could not observe every operation as it was performed within the one hour allotted for the walk through. Therefore, the researcher made selections and got the team's feedback. The team wanted to physically walk through each area in which work is performed to get a sense for distances and the flow of work. At a minimum, the team wanted a "talk through" on each activity. Before the team began, the co-leader/researcher instructed the team in how to detect waste.

The section supervisor provided the talk through and demonstrations of the cylinder preparation process. The team wanted to see where the operator prepared cylinders. The location of the vacuum and purge equipment were noted. The location where the operator moved the prepped cylinders once done was taken in consideration. The team noted lot of transport activity and setup, both of which are forms of waste.

The waste did not materially contribute to the final product but did consume resources. The value of the walk through was evident. First, the team saw that the preparation activity inside the blending process repeated work done in maintenance. The activity involved scraping off old labels (usually four, some of which do not come off easily) and doing touch-up painting of bare spots on the cylinders.

The team noted lot of rework, interruption activity and setup, all of which are forms of waste. With the walk through over, the team members regrouped to pool all observations. The team shared instances of waste detected. The team made 32 non-redundant observations of waste during the walk through. The team categorized this list by type of waste. Categorising involved looking at each observation, deciding what type of waste it represented, and recording it.

The waste observation form was used record the observations, shown in appendix B. The activity provided the team an opportunity to practice what it had learned about the different categories of waste prior to the walk through.

The activity provided the team with a rapid visual assessment of which types of waste were most dominant in the work process. The team needed this analysis to build fact-based direction (i.e., mission, goals, and do's and don'ts). Travel/transport and setup were the forms of waste with the most examples; the categories of wait, searching, inspection and interruption were next in order of frequency of observations. With respect to travel/transport, the operator had to travel to get labels, valves, nets, leak soap, wrenches, and orders. Every step used time. In addition to the process map, the team drew the spaghetti chart.

The chart was a representation of movements of the operator while performing a specific task, shown as figure 10 in chapter 4. The chart illustrated the travel or movement of the operator by drawing lines to depict these movements. The workplace layout sheets and a pencil were used so that a graphical image of the amount and orderliness of operator movement, as required by the job, can be displayed. Almost all the preparation work process and most of the blending work process was setup. Each involved getting cylinders ready for reuse or preparing them for machine operations (vacuum, purge, vent, and roll).

During these machine operations, the operator waited. Workers also waited for orders to be processed and put into the pickup bin. The normal processes of prepping and blending were each interrupted by having to sort cylinders, make repairs, deal with power surges, and answer questions about orders. Equipped with the profile of waste in the work process, the team was ready to build the mission, goals, and do's and don'ts that would give guidance during the remainder of the week.

3.2.3 Build the mission statement.

After performing the walkthrough of the target work process, it became clear to the researcher that there were a lot of wastes within the process. The researcher and the team built the mission statement. Building the mission statement was not difficult because the researcher is a trained and qualified kaizen practitioner, to perform the task.

A mission statement had three components: a "To" statement that stated the business problem the event was attempting to eliminate or otherwise improve; a "For" statement that said who will benefit, and a "By" statement that indicated what will be fixed.

Building the mission statement required the team to work from the waste observed to the effects it had on overall performance of the work process. The team members then took the work process problem and asked how that affected business success. The mission statement was then developed, to ensure customer satisfaction with on-time delivery by reducing cycle time of cylinder preparation for APSAP TYY LTD and all its stakeholders. APSAP had to make sure empty cylinders are prepared and sent to the production area in time for filling with gas. The goal would be achieved by improving the reducing cycle time and eliminating waste in the preparation section. The mission statement is as shown in figure 2 below.

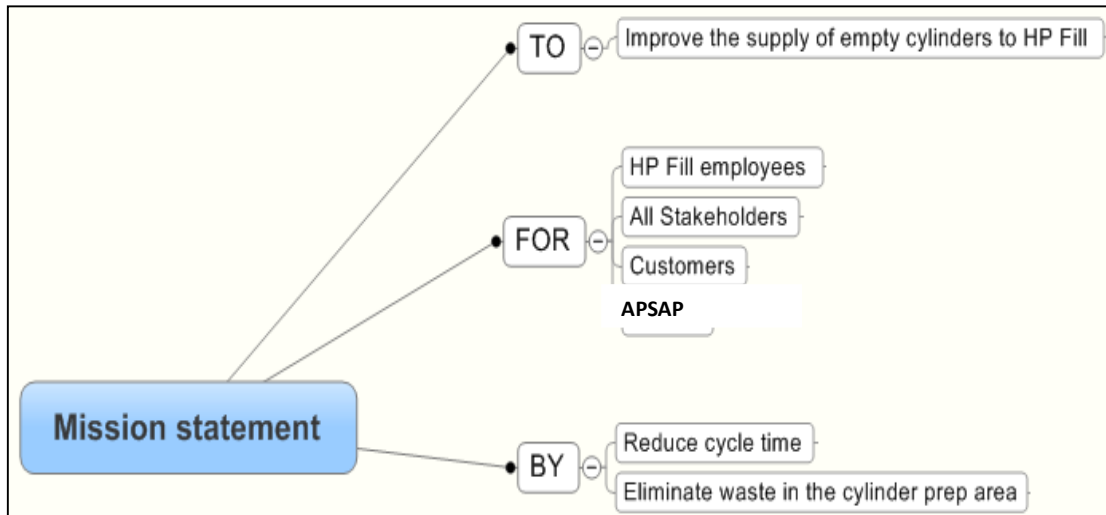


Figure 2. Mission statement: (Source: Researcher, 2007)

Building the mission statement assisted the researcher and the team to review major sources of wastes uncovered during the walk through of the work process. The researcher can determine major sources of wastes that impair the performance of the work process. The researcher discovered how the poor work process performance negative affect business success. The fourth step was to set goals.

3.2.4 Set goals for the manufacturing kaizen event.

Setting the goals was even easier than defining the mission. Basically, the team took the top five forms of waste discovered during the walk through and stated a goal to reduce the presence of each. The goals were set based on the walk through. The goals were, (1) reduce travel and transport by 50%, (2) reduce setup by 40%, (3) reduce wait time by 70%, (4) reduce rework by 50%, (5) reduce searching time by 60%, (6) eliminate all hazard items, and (7) reduce interruptions by 90%. The team estimated an amount of reduction based on what was seen and how much change the team felt was needed to improve the work process and produce the promised business results.

The researcher checked the goals set based on the walk through with those set based on the scope document. Consistent was seen, however, the walk through provided a better set of goals than the scope document. The walkthrough built the goals using far more information than was available from the scope document. The team accepted the goals based on the walk through. The goal state was then clearly defined in figure 3 below.

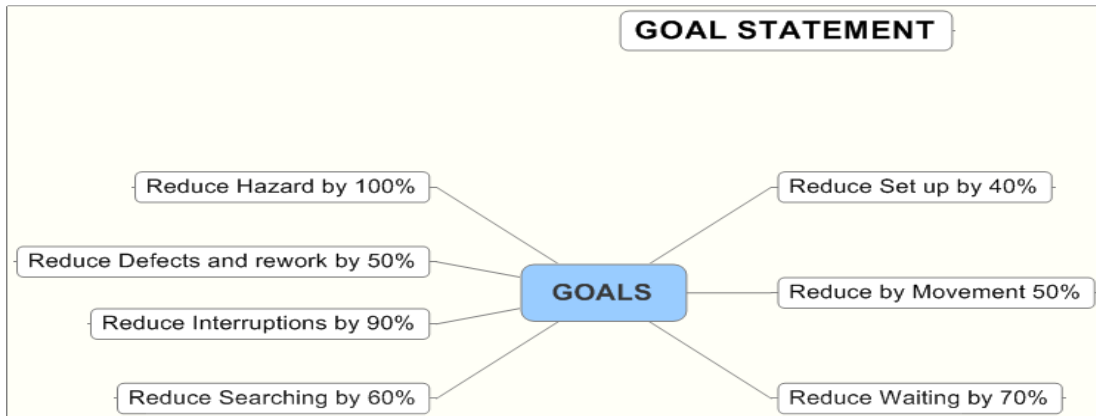


Figure 3. Goal Statement: Source: Researcher, 2007)

3.2.5 Define the Do and Do Not



The researcher then reviewed the do and do not provided by the stakeholders. The team determined if there were any additions or subtractions to the "must do" and the "do not". All the approved do and do not were documented in the manufacturing kaizen event folder see figure 4 below.

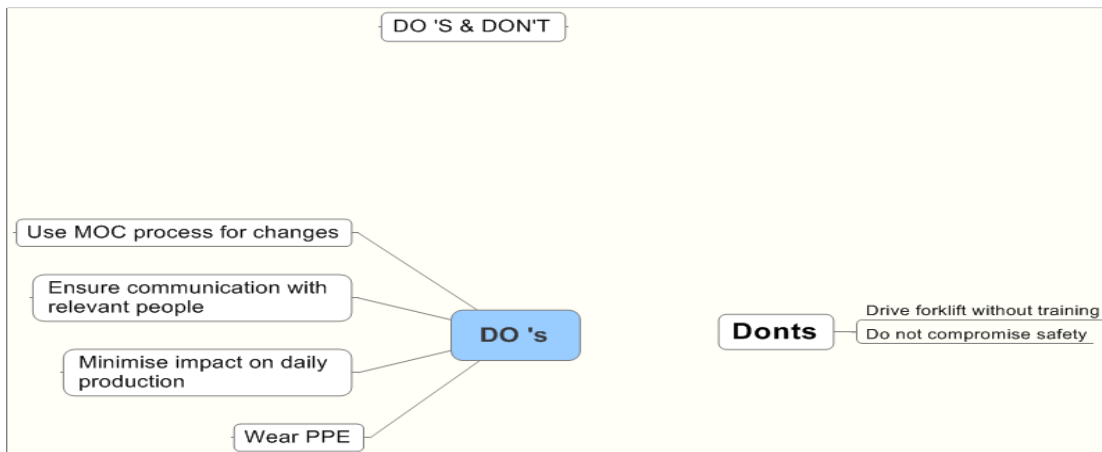


Figure 4. The Dos and Don'ts: (Source: Researcher, 2007)

In all cases when the manufacturing kaizen event is performed, the team has to abide by company polices and has to follow a correct protocol to make changes. The figure indicates that all team members had to wear personal protective clothing (PPE). The team has to fill in a management of change (MOC) to make any operational changes. The team had to communicate with relevant stakeholders before making any change in order to minimize the impact on production during the manufacturing event. There were also some activities that the team cannot do, i.e., no one was allowed to drive the forklift without been trained and no one should compromise safety.

3.3 Data interpretation and analysis

The researcher documented the information about each process. The information was later entered into the process flow recap sheet, shown as Table 3 and 4 in chapter 4. The spreadsheet automatically computed a summary and distribution of value added and waste. The team could easily analyse activities once information gathering was finished.



3.4 Summary

In this chapter a description of the target work process and the spaghetti chart were then built. The overview information for the work process was captured. The target work process' was easily identified. The team conducted the walk through and approached each workstation in the order specified in the walk through plan. Observations were made as the workstation was approached. The team identified a work activity, and then decided if the activity is value adding or waste.

All these observations of waste were noted. The researcher reviewed the five major sources of waste uncovered during the walk through of the work process. Component of each goal was then built and was stated how much or how well each change will be accomplished.

The researcher then reviewed the "do and do not" to make sure of the boundaries. Each team member was given a role to perform in this data collection exercise. Chapter 4 reveals all the results found from the data collection exercise. The chapter shows all the performance issues identified. Chapter 4 also explains how the team resolved the problem by generating ideas that can illuminate or reduce the unnecessary waste in the work process. An experiment or pilot would then be conducted by implementing the generated ideas to see if there was any improvement in the process. Chapter 4 will clearly outline the results, interpretation and analysis of all the information captured in data collection in a form of graphs and tables.

Chapter 4:

4. Presentation of findings and results

4.1 Introduction

Chapter 4 outlines the findings and analysis of all the information captured in data collection. The findings are also presented in a form of graphs and tables. Post implementation results are also presented and analysed in the chapter. The automated process flow recap sheet, shown as table 3, was used to analyse the amounts and sources of waste. The spreadsheet documented an activity, time and distance. Each work activity was assigned to the category of value added or a category of waste.

The spreadsheet was designed to compute the value-added ratio and total time per waste category and to chart the information depicting the distribution of time by value added and waste categories. Firstly, the findings captured during the observation are presented. Secondly, ideas are generated and implemented to improve the findings. Finally, the presentations of the results post implementation of ideas are discussed.

4.2 Presentation of findings

An observation of 32 activities was noted in order to complete the cylinder preparation work process. Two observations of the cylinder preparation work process seemed to show a consistent estimate of cycle times. The process was made up of three types of work: (1) paperwork (getting, reviewing, filling out, filing, organizing, and discarding forms, tags, and orders); (2) readying the cylinders for preparation (locating and getting cylinders, checking the cylinders for damage, hooking cylinders up to the manifold); (3) and prepping the cylinders (venting, vacuuming, and purging their contents). Interspersed through the process were travel, interruptions, set up time, waiting, inspection and search for paperwork and cylinders.

The cycle time observed for preparation of a batch of cylinders was 22 minutes, and 11 seconds. None of the activities could be classified as value adding. None materially produce the product the customer seeks, that was, gas. The process took a used cylinder and refurbished it for reuse by the company. Cylinder reuse was the standard approach in the industry to providing vessels for transporting the customer's gas and controlling cost. The entire process, however, existed by the choice of the producers. The customer had not specified that the wanted gas should be in a used cylinder, for example. The team recognized that the customer had indicated that price was an issue.

The company then decided that reusing cylinders would help address that concern. The calculation was the producer's judgment and satisfied the producer's assessment of what was felt could be done. The fact remained that the customer had not requested this solution. If a customer did specify that the gas to be received be delivered in recycled cylinders, then at least some portion of the work process would be value adding.

The process flow recap sheet details all task descriptions with duration and distance described for each activity. It also enables classification of activity descriptions with respect to type of waste (e.g. movement, waiting, inspection, etc.). Therefore, the various waste types were arranged accordingly and captured in the process flow sheet, with total durations and distances calculated by means of a stop watch and measuring wheel, respectively. A total cycle of 22:11 min was captured for the process, as shown in table 3 below.

Table 3. Process Flow Recap Sheet before: (Source: Researcher, 2007)

CONTINUOUS IMPROVEMENT DEPARTMENT: PROCESS FLOW RECAP SHEET 2008/11/06						
<u>Process name:</u>		Sorting & Picking of empty cylinders (Before)				
<u>Process date:</u>		2007/12/11	<u>Center:</u>		Kempton Park - Package Gas	
Code	Description	Start time	End time	Duration	Distance	Type of waste
1	Searching for demand / order	00:00:00	00:00:34	00:00:34	0	SEARCHING
2	Moving to Fill station	00:00:34	00:00:58	00:00:24	34	MOVEMENT
3	Inspecting order form	00:00:58	00:01:23	00:00:25	0	INSPECTION
4	Communicate demand to operator	00:01:23	00:01:53	00:00:30	0	SETUP
5	Search for loader Foreman	00:01:53	00:02:23	00:00:30	7	INTERRUPTION
6	Waiting for loader Foreman	00:02:23	00:03:37	00:01:14	0	WAITING
7	Communicate to loader Foreman	00:03:37	00:03:48	00:00:11	0	SETUP
8	Travel to empty storage area	00:03:48	00:04:20	00:00:32	65	MOVEMENT
9	Searching for product / cylinders	00:04:20	00:04:40	00:00:20	7	SEARCHING
10	Searching for product / cylinders	00:04:40	00:04:50	00:00:10	5	SEARCHING
11	Searching for product / cylinders	00:04:50	00:05:40	00:00:50	10.4	SEARCHING
12	Found product / cylinders	00:05:40	00:05:50	00:00:10	0	SETUP
13	Travel with pallet to HP	00:05:50	00:06:00	00:00:10	72.2	MOVEMENT
14	Off loading pallet	00:06:00	00:06:10	00:00:10	1.8	MOVEMENT
15	Travel to empty storage area	00:06:10	00:06:51	00:00:41	69	MOVEMENT
16	Searching for product / cylinder	00:06:51	00:06:54	00:00:03	0	SEARCHING
17	Travel with pallet to HP	00:06:54	00:07:25	00:00:31	65.8	MOVEMENT
18	Communicate to operator	00:07:25	00:08:23	00:00:58	0	SETUP
19	Operator search for foreman	00:08:23	00:10:29	00:02:06	93	INTERRUPTION
20	Communicate to foreman	00:10:29	00:10:43	00:00:14	0	SETUP
21	Foreman walk to sorting area	00:10:43	00:12:16	00:01:33	107	MOVEMENT
22	Searching for product / cylinder	00:12:16	00:13:10	00:00:54	22	SEARCHING
23	Look for sorter	00:13:10	00:14:35	00:01:25	87	INTERRUPTION
24	Communicate to sorter	00:14:35	00:14:39	00:00:04	0	SETUP
25	Waiting for sorter	00:14:39	00:16:31	00:01:52	0	WAITING
26	Sorter gets out of F/L	00:16:31	00:16:39	00:00:08	2	MOVEMENT
27	Searching for product / cylinder	00:16:39	00:16:50	00:00:11	0	SEARCHING
28	Sorting pallet	00:16:50	00:20:16	00:03:26	24	SETUP
29	Strapping cylinders to pallet	00:20:16	00:20:27	00:00:11	0	SETUP
30	Moving to F/L	00:20:27	00:20:30	00:00:03	3	MOVEMENT
31	Moving pallet to HP area	00:20:30	00:22:00	00:01:30	102	MOVEMENT
32	Placing pallet in position @ HP fill area	00:22:00	00:22:11	00:00:11	2	SETUP
PROCESS FLOW RECAP SHEET 2008/11/06						
<u>Process name:</u>		Sorting & Picking of empty cylinders (Before)				
<u>Process date:</u>		2007/12/11	<u>Center:</u>		Kempton Park - Package Gas	
Code	Description	Start time	End time	Duration	Distance	Type of
TYPE OF WASTE				DURATION	DISTANCE	
INSPECTION				00:00:25	0	
INTERRUPTION				00:04:01	187	
MOVEMENT				00:05:42	521.8	
SEARCHING				00:03:02	44.4	
SETUP				00:05:55	26	
WAITING				00:03:06	0	
TOTAL				00:22:11	779.2	

The activities relating to assorted waste types were presented graphically as figure 5 below. This portrays all waste identified in the process, which were described in terms of time (minutes) and captured on the process flow recap sheet. In this respect, activities categorised as waste during the task were due to the fact that they caused loss of productive time, these were classified as follows:

- 5:42 minutes of movement: Delineated as waste created by the operator moving about while performing a task. Unnecessary movement also included movement of personnel away from workstations; movement of parts, materials, and information around the workplace or between locations; as well as change in position by the operator (e.g. turning, bending, lifting) while at the workstation.
- 03:06 minutes of waiting: Defined as waste created by delay in work activity. Typically this could occur while waiting for some needed resource to become available or while awaiting receipt of approval to proceed.
- 04:01 minutes of interruption: Described as waste created by stoppage in work activity due to an external factor (e.g., mechanical breakdown, phone call, organizational support, etc). In addition to productive time being lost during the period of interruption, time and materials are expended in attempting to correct a malfunction or search for a replacement.
- 03:02 minutes of searching: Explained as waste created by an activity required in locating a needed resource (e.g. person, tool, part, or information).
- 00:25 minutes of inspection: Depicted either as completion of unnecessary paperwork or as waste created by assessment of defects by a workstation that is different to the producing workstation and is typically one dedicated to quality control. In this instance waste derives from the addition of production cost, along with substitution of personalized quality control by external quality control.
- 05:55 minutes of setup: Delineated as waste created by labour required in preparing a performer, a machine, or a process, to execute a task, or change from one work process or product, to another.

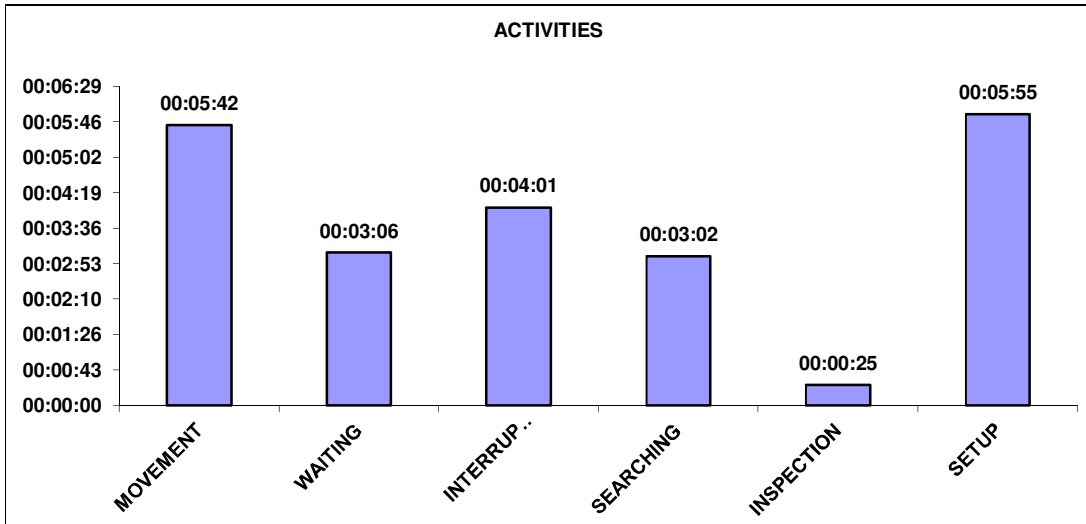


Figure 5. Activity bar chart before: (Source: Researcher, 2007)

Figure 6 presents the distribution of waste observed in the cylinder preparation work process in form of a pie chart. Almost 27% of the work time was consumed in set up for machine operations to finish. These machine-driven operations were vacuuming the cylinders and purging any remnants of old products. The team observed that if it could speed up these machine operations, it could greatly reduce waste in the work process. The remainder of the time was used in interrupting activities (18%), inspection (2%), travel/transport (26%), waiting (14%) and search (14%).

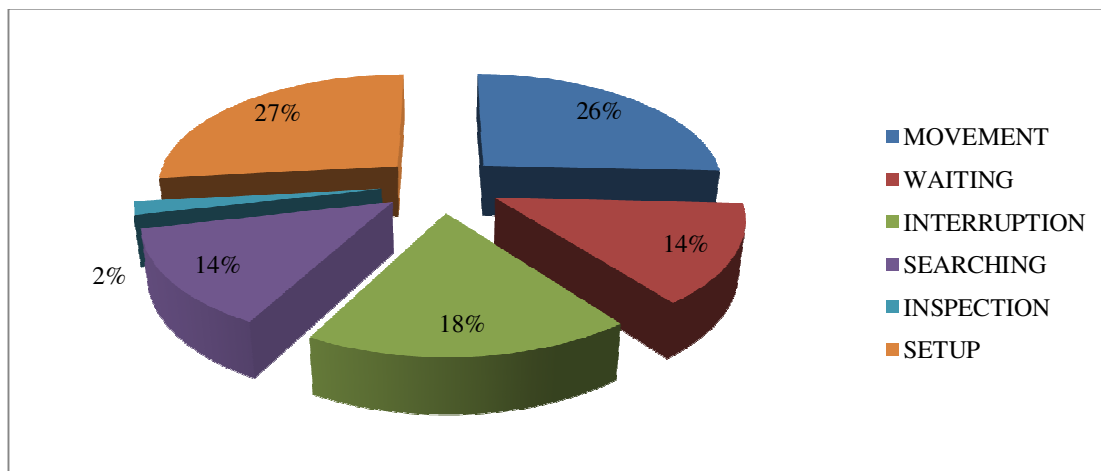


Figure 6. Activity pie chart before: (Source: Researcher, 2007)

4.3 Generating and implementing ideas

The results reveal a need for improvement in performance. These issues could be resolved by generating ideas that would eliminate or reduce unnecessary waste expenditure in the work process. Figure 8 demonstrates the ideas conceived, of which the best means to achieve the Kaizen event's goals and elevate performance of the target work process were selected.

In terms of process improvement, six main activities were identified for completion. These included : (1) generation of ideas for improvement; (2) trimming of generated ideas; (3) conducting an experiment; (4) selection of specific ideas; (5) creation of an action plan for execution of ideas. An experiment would only be conducted if it needed to test whether an idea would be effective in eliminating waste.

4.3.1 Generate improvement ideas

Two primary techniques were applied in generating ideas for improvement, which included brainstorming and the "asks an expert" approach. During the brainstorming exercise, whatever ideas came to mind on waste elimination, were voiced by team members. In this instance, the input of employees in the work process were taken into consideration, as were some of the inputs collected during the walk-through phase. In applying the manufacturing kaizen method, brainstorming sheets were constructed as a focus aid. Each sheet consisted of one flipchart page on which a separate goal was recorded. Examples of waste targeted by the specific goal were then listed beneath.

These consisted of the most resource-consuming waste activities that were detected during process observation. Generation of improvement ideas ensued, and was applicable to brainstorming solutions for one goal at a time, at a time limit of 10 minutes per goal. Ideas were recorded as team members offered them with any idea being accepted and listed.

The conventions stipulated for the exercise were: (1) one speaker at a time; (2) members were permitted to share whatever came to mind; (3) no idea could be judged; (4) idea generation should continue until the allocated time limit was reached. Once the brainstorming process for all goals had been completed, the input of employees' ideas on ways to improve the work process was incorporated into each goal.

4.3.2 Trimming of generated ideas

After generating improvement ideas for each goal, the team's task was to review each idea and explore whether it was worth pursuing further. The concern was that, for a given idea, the sense of the team was that doing the improvement would not be prohibitively costly. The idea would be effective in advancing the achievement of the goal, and would not harm safety. If an idea satisfied these concerns, it was retained. If it did not, it was dropped from further consideration.

If the team was uncertain about the idea, an experiment was performed to test the question about which the team members were unsure. The key to trimming process was having the team thoroughly explore each idea with the person who offered it. After discussing each idea for improving the cylinder preparation process, the team voted whether each was worth pursuing. All the ideas passed the "worth pursuing" test.

4.3.3 Conduct an experiment

An experimental approach was used to test the effectiveness of the suggested improvement ideas. The experiment provided information needed to rate the value of an idea in eliminating waste. It was structured in accordance with a template that served to guide the research team in defining the question under exploration. In addition, the experimental protocol proved useful when the team submitted formal requests for an amendment to work standards.

Added to the protocol were the actual findings of the experiment and these were submitted as evidence in support of the above- mentioned requests. The protocol for the rolling experiment is presented in Figure 7, along with the results found.

The experiment was then concluded and the results reported. The experiment appeared to validate the effectiveness of tested improvements; consequently, the list of ideas for implementation required no adjustment.

Experiment: Testing the Effects of Reduced Rolling Time	
Purpose	Determine whether reducing the current standard rolling time cylinders from 10 minutes to 5 will produce an adequate mixing of gases.
Conducted By	Gift Sizwe Nhlabathi, Peter Vera and Justice Siala
Total Time	30 minutes
Hypothesis	If we compare the mix achieved after rolling a sample of three cylinders of the most complicated non-flammable blend for 5 minutes with the mix realized after rolling for 10 minutes, then we will observe no difference.
Resources	Three B-size cylinders each with a blend of 10% N ₂ /He. This blend of gases is the most difficult for which to achieve a proper mix.
Measure	Analyze gas to determine mix.
Decision Rule	If we find that the mix of the N ₂ /He gases analyzes at 10% for each cylinder after 5 minutes of rolling, then we will conclude that rolling for 5 minutes is effective.
Description	A 10% N ₂ /He mix was blended in three B-size cylinders. The N ₂ (the heavier component) was added first; the He was added second. Three cylinders were rolled on a cylinder rolling device for 5 minutes. The cylinders were analyzed, and the level of mix achieved was compared to the target level (10%).
Results	The mix in each cylinder analyzed at 10% after 5 minutes of rolling, the same result achieved by rolling for 10 minutes.
Conclusion	Five minutes is sufficient to allow mixing of gas components when the heavier gas is added first and the lighter gas second.
Learning	No additional learning.

Figure 7. Experiment: Testing the Effects of Reduced Rolling Time: (Source: Researcher, 2007)

4.3.4 Select improvement ideas

The most effective ideas were afforded precedence, whilst those that remained were placed on a follow-up action list to be pursued after the event. During the event, improvement ideas selected for execution were listed on a separate flipchart page as shown in figure 8.

Improvement Ideas
Establish a lower minimum purge pressure.
Reduce the level to which cylinders need to be vacuumed
Hook unused vacuum pump in tandem to current vacuum pump to speed vacuum and purge operations.
Install hand wheels on pigtails of the prep manifold to speed hook-up of cylinders.
Have storage bins for each type of cylinder valve adapter mounted on manifold.
Replace wrenches used in hook-up operations and have a separate set for prep area.
Organize cylinders in storage area by expiration date
Shift preparation of 296 Ar/O ₂ to blending area.
Place trip protector over exposed line from computer network to printer.
Counsel worker on use of earplugs.
A inbox tray to be placed on the foreman's desk for demand orders only.
Design new layout at the empty cylinder bay area.
Create a no parking area in front of the empty cylinder bay
Two way radios to be introduced to improve communication.
Allocate a fork lift only for HP fill
Allocate a specific area for trucks to park. Use the customer co-ordinator to sort cylinders
Implement visual signs in the empty cylinder bay
Convert unused N ₂ cylinders to CO ₂ cylinders
Out of date cylinder to routed to maintenance department by the customer co-ordinator

Figure 8. List of Selected Improvement Ideas (Source: Researcher, 2007)

4.3.5 Create action plans and execute improvement Ideas

Prior to implementation of any changes, each improvement idea was reviewed to identify possible areas that may create complications. In this respect, an action plan was developed to facilitate implementation. An action template used is shown as appendix E.

This ensured that the required resources could be obtained, and that the actions assumed to successfully execute improvements were well defined. Safety procedures were also reviewed to ensure that person-protective clothing was used. Albeit that some aspects required greater effort than others, overall, the implementation phase proved to be successful.



4.4 Presentation of results

Data was collected following post implementation of ideas. This was once more recorded manually on the waste observation sheet and then on the flow process recap sheet as shown in table 4 below; these results were then compared to the process flow recap sheet applied for the walk-through phase to discern whether any improvement occurred. The comparison revealed that the cycle time was reduced from 22:11 minutes in the walk-through phase to 06:44 minutes following idea implementation, denoting an improved time of 15:67 minutes. Furthermore, the numbers of steps involved in the process were minimized from 32 to 15 resulting in a 53% rate of improvement.

Table 4. Process Flow Recap Sheet after: (Source: Researcher, 2007)

CONTINUOUS IMPROVEMENT DEPARTMENT						
PROCESS FLOW RECAP SHEET						2008/11/06
Process name: Sorting and Picking of empty cylinders (After)						
Process date: 2007/12/13			Center: KMT Park Package Gas			
Code	Description	Start time	End time	Duration	Distance	Type of waste
1	Foreman checking orders	00:00:00	00:00:14	00:00:14	0	INSPECTION
2	Foreman communicate to operator	00:00:14	00:00:24	00:00:10	0	SETUP
3	Operator moving to empty cylinder bay	00:00:24	00:01:10	00:00:46	64.3	MOVEMENT
4	Picking up pallet	00:01:10	00:01:18	00:00:08	2	MOVEMENT
5	Moving to HP Fill	00:01:18	00:02:36	00:01:18	66	MOVEMENT
6	Positioning pallet	00:02:36	00:02:46	00:00:10	1.9	MOVEMENT
7	Foreman communicating to Operator	00:02:46	00:02:50	00:00:04	0	SETUP
8	Operator moved to empty cylinder bay	00:02:50	00:03:47	00:00:57	60.4	MOVEMENT
9	Operator communicate to Foreman - No	00:03:47	00:03:57	00:00:10	0	SETUP
10	Foreman communicate to sorter	00:03:57	00:04:16	00:00:19	0	SETUP
11	Foreman communicate to Operator	00:04:16	00:04:25	00:00:09	0	SETUP
12	Operator move to sorting bay	00:04:25	00:05:22	00:00:57	58.3	MOVEMENT
13	Pick-up pallet	00:05:22	00:05:36	00:00:14	0	MOVEMENT
14	Operator move to HP Fill	00:05:36	00:06:35	00:00:59	67.5	MOVEMENT
15	Operator positioning pallet at HP Fill	00:06:35	00:06:44	00:00:09	1.8	MOVEMENT
TYPE OF WASTE						
				DURATION	DISTANCE	
INSPECTION				00:00:14	0	
MOVEMENT				00:05:38	322.2	
SETUP				00:00:52	0	
TOTAL				00:06:44	322.2	

In addition, total durations and distances were calculated for the various categories of waste types, the interpretations of which are discussed in the activity bar chart. Figure 9 represents all categories of waste involved in the process that were captured on a new process flow recap sheet, which are indicated in terms of time (minutes). However, waiting, interruption and searching times have been eliminated. It demonstrates the improvement in process cycle times and distance. Inspection times were shown to be reduced from 00:25 minutes to 00:14 minutes, an improvement of 11 minutes, set up times were reduced from 05:55 minutes to 00:52 minutes, while movement times were reduced from 05:42 min to 05:38 min.

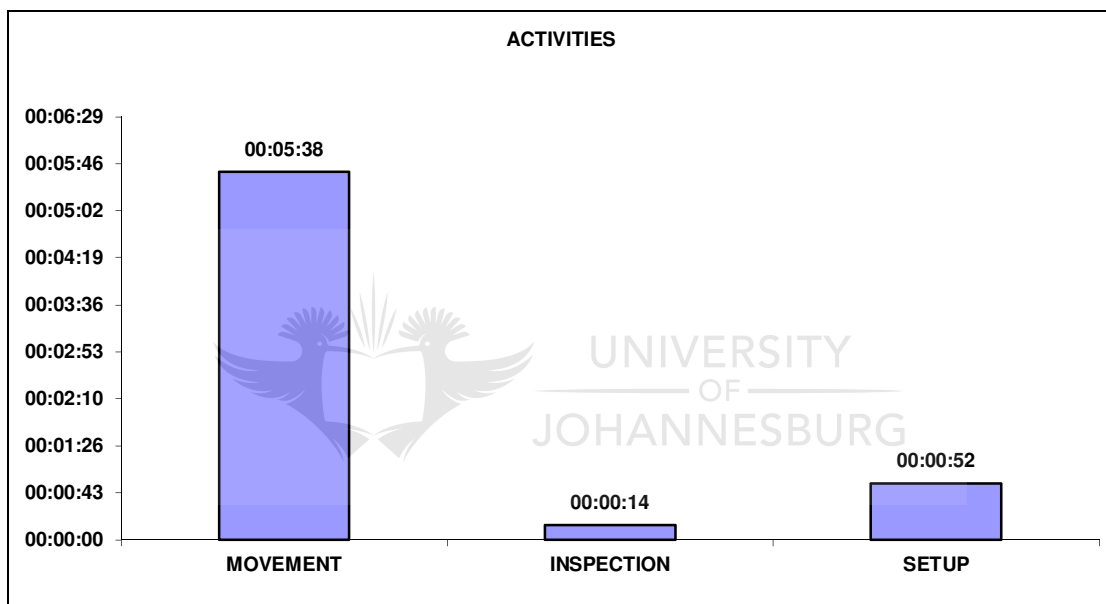


Figure 9. Activity bar chart after: (Source: Researcher, 2007)

4.5. Analysis of results

4.5.1 Operating improvements

Measures of improvement that occurred from the original walk-through results, in comparison to results reported post implementation of ideas are summarised in table 5. It was also determined, that waste reduction notwithstanding, implementation of ideas resulted in financial benefit, where a cost saving of R251 020.80 was achieved by returning scrap material, back into the system.

It is evident from measures shown in table 5, that an intervention to improve the process was indeed required. In this respect, significant improvements were made by utilising manufacturing kaizen, with rates of improvement indicated as 58.6% on distance measured, 70% on the total cycle time and 1.17% on movement time.

The minimal rate of improvement on movement time may have been due to the complexity of facility layout which inevitably led to a fair amount of travelling. Times indicated for waiting, interruption and searching were eliminated by a rate of improvement of 100%. Inspection and setup times were reduced by 44% and 85.35%, respectively. The scrap rate dropped by 100%, while labour utilization increased by 242.28%.

Table 5. Summary of Improvements sheet: (Source: Researcher, 2007)

	Original Finding	Post Change Finding	Improvement
Movement			
Distance (in meter)	779.2	322.2	58.6%
Status of Human Operations			
Cycle time (in hours)	00:22:11	00:06:44	70%
Value Added Ratio (VAR)	0.00	0.00	
Travel/Transport	00:05:42	00:05:38	1.17%
Motion	00:00:00	00:00:00	
Wait	00:03:06	00:00:00	100.00%
Interruption	00:04:01	00:00:00	100.00%
Search	00:03:02	00:00:00	100.00%
Inspect	00:00:25	00:00:14	44.00%
Rework	00:00:00	00:00:00	
Setup	00:05:55	00:00:52	85.35%
Store	00:00:00	00:00:00	
Unnecessary Processing	00:00:00	00:00:00	
Hazard	8	4	
Other Impacts			
Inventory			
	0	0	
	0	0	
Materials or Supplies			
	0	0	
Energy or Other Utilities			
	0	0	
	0	0	
Equipment or Tools			
	0	0	
Facility (sq. feet needed)	0	0	
Scrap or Waste	180	0	100.00%
Labor productivity (output units per person hour)	2.72	9.31	242.28%
Throughput (units per line per day)	0.00	0.00	

4.6. Visual presentation of improvements in movement shown using the spaghetti chart before and after

The spaghetti chart shows all the movement of the operator around the workstation. The researcher physically went and created the chart to determine the traffic in the process, while the operator was doing a task. The chart is presented on figure 10 below. The improved spaghetti chart is shown after the implementation of ideas using the manufacturing kaizen, shown as figure 11, below. Traffic within the process was identified and reduced. Hence there was reduction in travel time. The new spaghetti chart was then drawn and compared to the initial one. Huge changes were immediately noticed. Less traffic was observed on the improved chart.

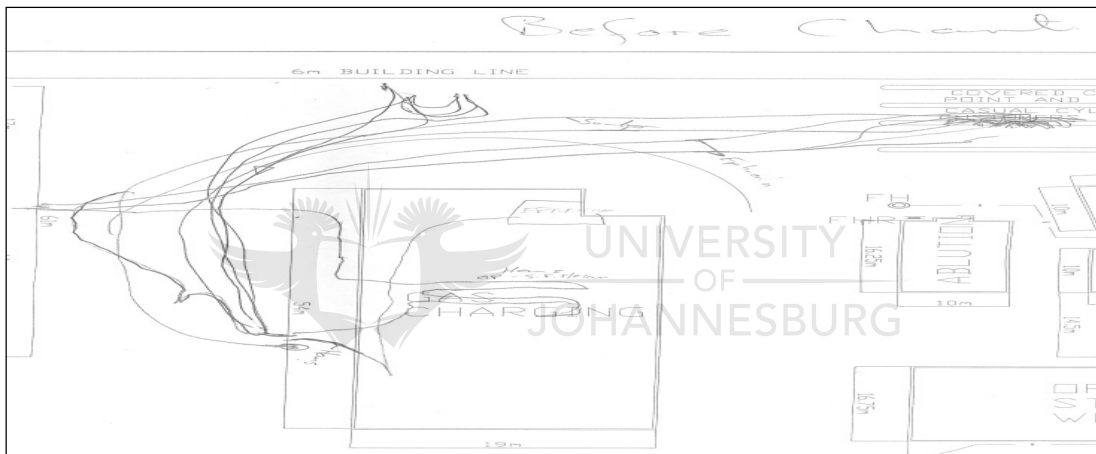


Figure 10. Spaghetti chart before :(Source: Researcher, 2007)

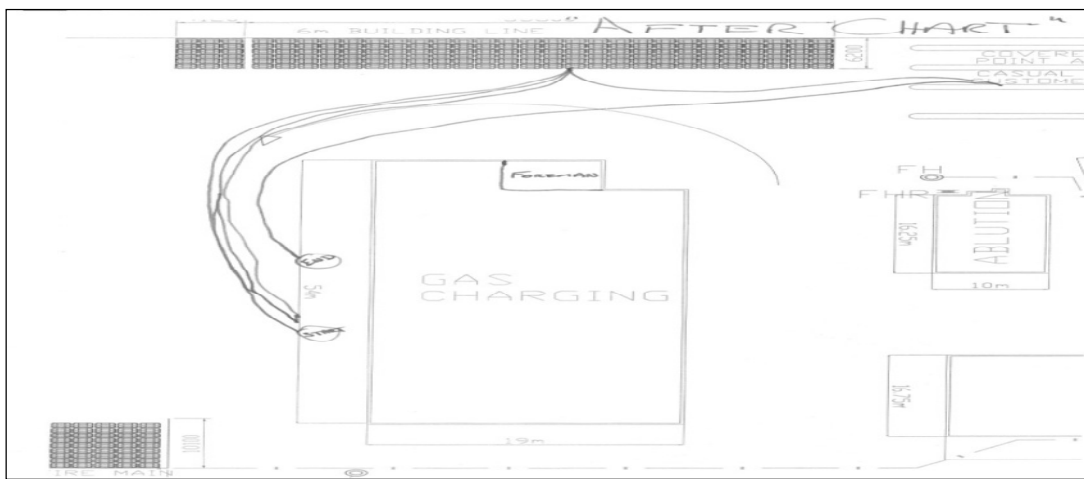


Figure 11. Spaghetti chart after :(Source: Researcher, 2007)

4.7. Summary

The waste activities that contributed to the work process were revealed and plotted onto an activity flow recap sheet used to capture activities. An activity bar graph and pie chart were drawn to show the amount of contribution each type waste contributed in the process. Ideas were then generated by the team to reduce or eliminate these wastes in the process. Actions were taken by team to implement these ideas. When some of the ideas were implemented, a pilot study was the performed to see the impact of improvement these ideas brought.

Each team member had different roles in the pilot study. The comparison of activity flow recap sheets used to capture activities before and after implementation of ideas was discussed. A huge improvement was seen after implementing most of the ideas that were generated. The results were also substantiated by showing the comparison of activity bar graph of waste observed during data collection before and after implementation of ideas.

A summary of improvements sheet was used to clearly to communicate the amount of improvements from original findings to post findings. Furthermore, a visual presentation of improvements, were shown by using the spaghetti chart before and after. The charts showed the reduction in traffic while the operator was performing a task. Based on the results, it was clearly evident that manufacturing kaizen was the correct tool to use to improve this process. The next chapter will discuss the summary of the research and conclusions. It will also highlight the possible areas for future research.

Chapter 5

5. Summary and conclusion

5.1 Summary

The research detailed the application of a lean manufacturing tool (Manufacturing Kaizen) in the improvement of a work process at APAS Pty Ltd. The necessity for this concept derived from the fact that the company appeared unable to meet high consumer demand, where gas cylinders could not be prepared in time for the purpose of filling, thus creating a backlog in production. Increased construction and mining activities in South Africa were believed to play a contributory role to the problem.

The goal was to reduce the identified waste using manufacturing kaizen tool. Waste reduction eventually reduced the cycle time of the work process. The primary objective of the thesis was to study and analyze the cylinder preparation process in APSAP PTY LTD. The process activities were captured, then analyzed using the process map. The secondary objective was to identify waste in the process.

In seeking a possible solution, manufacturing kaizen was applied, which showed a perceptible rate of improvement to cycle times of the cylinder preparation process. The research elucidates the manner in which the process was analysed by means of a process map, in order to identify waste formation. Ultimately, the goal was to demonstrate how implementation of manufacturing kaizen could be an effective tool in minimizing waste and so improve the work process to increase production.

Data collection was conducted by using the five steps applicable to manufacturing kaizen. The initial step entailed capturing of the process map, which was then used to review targeted work process information. This information was, in turn, applied in analyzing the process.

The second step involved conducting a walk-through the target work process, where sources of waste were identified. The types of waste the research team elected to focus on were those that contributed significantly to cycle times of the process.

A spaghetti chart plotted the movements of the operator during travelling and searching. The observations of the cylinder preparation process continued over a period of five hours a day. This enabled verification of the activities and allowed for certain activities to be repeated for confirmatory purposes.

The third step involved development of a mission statement, which plainly clarified the business problem. The fourth step entailed cultivating a goal statement, which consisted of dual components, namely a “what” that described the state of waste to be reduced and a “how much” that demarcated the particular amount of waste reduction. Furthermore, to enable specific focus to be placed on the scope of the event, defining the “do’s” and the “don’ts” were considered a final important step.

After the data from the walkthrough was collected, it was entered manually into microsoft word on the waste observation sheet by the team and further into the flow process recap sheet. It was concluded from the results that there is room for improvement. Performance issues were then resolved by generating ideas that can illuminate or reduce the unnecessary waste in the work process. The team then acted to improve the work process.

An experiment or pilot was then conducted by implementing the generated ideas to see if there is any improvement in the process. All generated ideas were then implemented. Data was again collected by following the operator doing his task. The wastes that contributed to the work process were revealed and plotted onto an activity flow recap sheet used to capture activities. An activity bar graph was drawn to show the amount of contribution each type waste contributed in the process.

A comparison of Activity Flow Recap Sheets was used to capture activities before and post implementation of ideas was presented. A comparison of Activity bar graph of waste observed during data collection before and after implementation of ideas was drawn. Then a summary of improvements was highlighted. Furthermore a graphic presentation of spaghetti chart before and after was presented, including the financial benefits of the manufacturing event.

With the improvement ideas executed, the team turned the efforts to measuring results. The step detected and quantifies the work process and business benefits produced by the Kaizen event. The information needed to verify whether the event achieved its mission and goals was provided. The Kaizen process measured both operating improvements and monetary benefits.

The team measured the operating improvements by repeating process observations of each work process doing a similar batch of work but now executed in a manner that incorporated the improvements made by the team. Measuring monetary benefits translates the operating and non-operating changes into rand savings or revenue gains, adjusting for the cost associated with implementing any of the changes. The team computed both hard and soft monetary benefits.

Hard monetary benefits are savings or revenue gains that begin to flow as soon as the event ends. Soft monetary benefits require an additional management action before they can be realized. In this event, hard monetary benefits were realized for the work processes the team modified. These replication benefits are judged "soft" because the managers at these sites will need to authorize the changes before the improvements can be made.

5.2 Conclusion

The results showed that with the introduction of manufacturing kaizen, labour productivity could be improved over time and resultant transformation would lead to enhanced productivity within the organization. The results also demonstrate that with the proper use of manufacturing kaizen, waste reduction can be achieved. This is highlighted by the 70% rate of improvement on cycle times which could make more time available for the production area to fill a greater number of gas cylinders. In this respect, table 6 below shows the results after this solution to the backlog of cylinder demand was implemented.

The overall results of the research indicated achievement of the specified goal for APSAP Pty Ltd and its stakeholders, to improve the rate of supply of empty cylinders to the filling area by reducing cycle times and waste in the cylinder preparation process.

The business was therefore, able to increase sales without a corollary increase in price. Customer satisfaction was also enhanced by improved and on-time delivery, reflected in a 51% increase in order intake, and a backlog decrease of 82% as shown in Table 6. In addition, results revealed a 100% reduction in scrap, resulting in revenue savings of R 251 020.80 and increased labour utilization of 242.28%. Comprehensively, these factors contributed favorably to improved productivity and occurred as a result of the application of Manufacturing Kaizen.

Table 6. APSAP PTY LTD: (Source: Researcher, 2008)

APSAP PTY LTD indicators		
(R million)	2007	2008
Sales	2,007	3,141
Order intake	1,977	3,831
Order backlog (Dec. 25)	4,772	541

With respect to the goals of the event, 4 out of 7 goals were exceeded (Table 7, Summary of goal achievement), however, this was less than expected. Whilst the do's and don'ts of the event were adhered to, both the level of participation exhibited by the kaizen team and the results of the kaizen participants' feedback indicated that team members were engaged, energized, and enabled in contributing to improvement in productivity of the business. All team members affirmed that the event was a positive learning experience, and overall rated it 8.5 out of 9.0 with respect to collective satisfaction.

Table 7. Summary of goal achievement: (Source: Researcher, 2008)

Summary of Goal Achievement			
Goals		Result	Status
Cylinder Preparation Process			
1	Reduce wait time by 70%	Down 100%	Exceeded
2	Reduce setup by 40%	Down 85.35%	Exceeded
3	Reduce travel/movement by 50%	Down 1.17%	Not met
4	Reduce interruptions by 90%	Down 100%	Exceeded
5	Reduce searching by 60%	Down 100%	Exceeded
6	Reduce inspection by 50%	Down 44%	Not met
7	Reduce cycle time	Down 70%	Met

Four out of the seven targets listed in table 7 were either achieved as expected or exceeded expectations. Waiting, searching and interruption times were completely eliminated, as expected.

Setup times were reduced by a rate of 85%, which exceeded the expected 40% by a rate of 36%. Inspection times were reduced by 44%, slightly less than the 50% expected, however the need for inspection was deemed valid in preventing compromise to the quality of the product. The minimal reduction on movement times occurred on account the current layout of the facility. However, the total cycle time was reduced by a rate of 70%, which could be regarded as a significant achievement in improving productivity for APSAP Pty Ltd.

5.3 Possible area for future research

This research addresses the application of one lean manufacturing tool known as manufacturing kaizen to improve the work process focusing in the chemical and gas industry. In future the focus will be extended to addressing the application of lean manufacturing concept to the continuous and discrete sectors with a focus on the mining industry. The goal of the research will be to investigate how lean manufacturing tools can be adapted from discrete to continuous manufacturing/mining environment, and to evaluate their benefits on a specific application instance.

Although the process and discrete industry share several common characteristics, there are where they are very different. Both manufacturing settings have overlap, but at the extreme, each has its unique characteristics. The research will attempt to identify commonalities between discrete and continuous manufacturing where lean techniques from the discrete side are directly applicable. These ideas will be tested on a large coal manufacturing company (referred to as company y) for now.

A value stream will be used to first map the current state and used to identify sources of waste and to identify lean tools to try to eliminate this waste. The future state map will be then developed for a system with lean tools applied to it. To quantify the benefits gained from using lean tools and techniques in the value stream mapping, a simulation model will be developed for company y and a designed experiment will be used to analyze the output of the simulation model for different lean configurations. Generalization of the results will also be provided.

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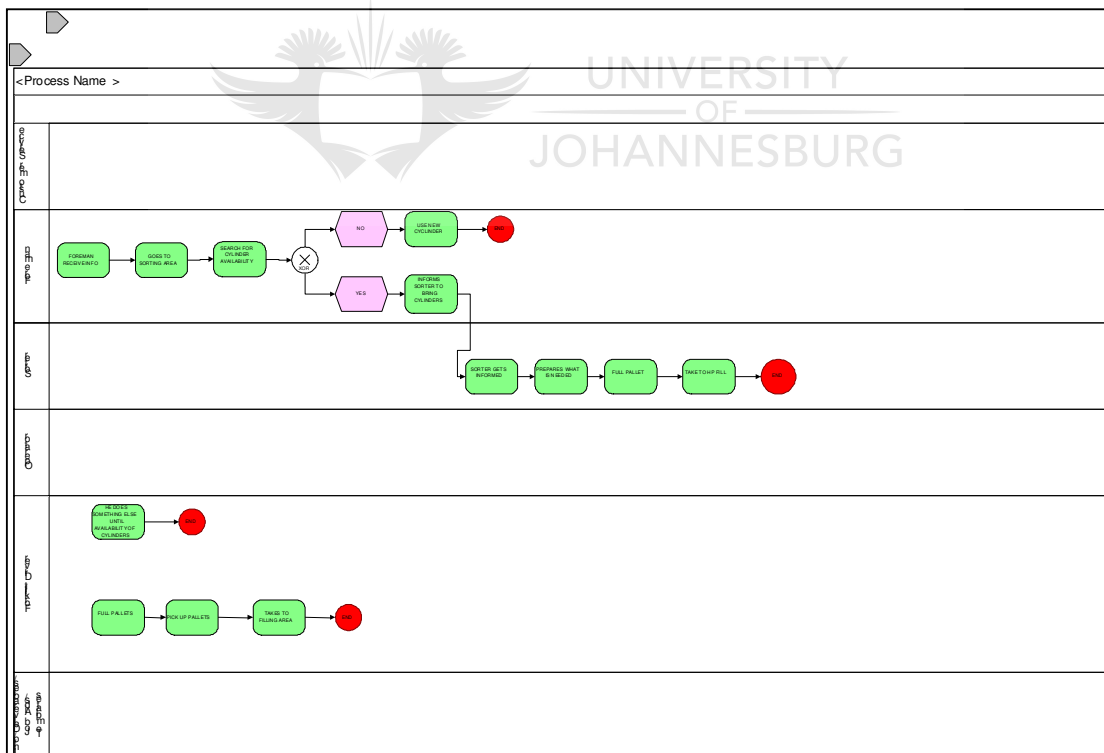
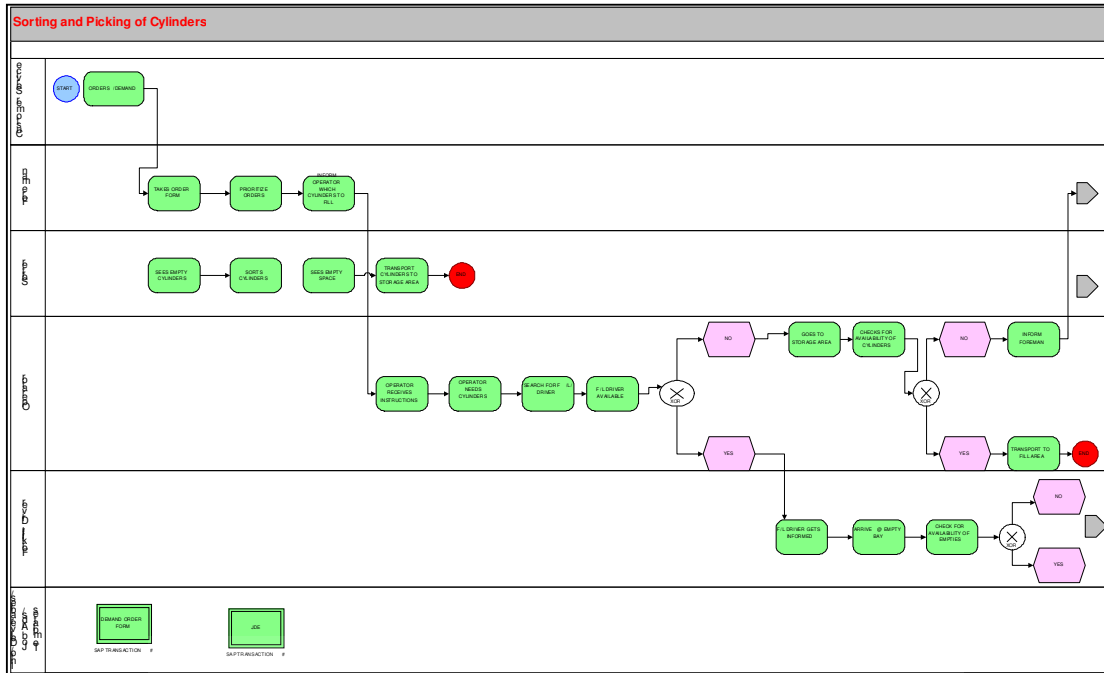
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APPENDIXES



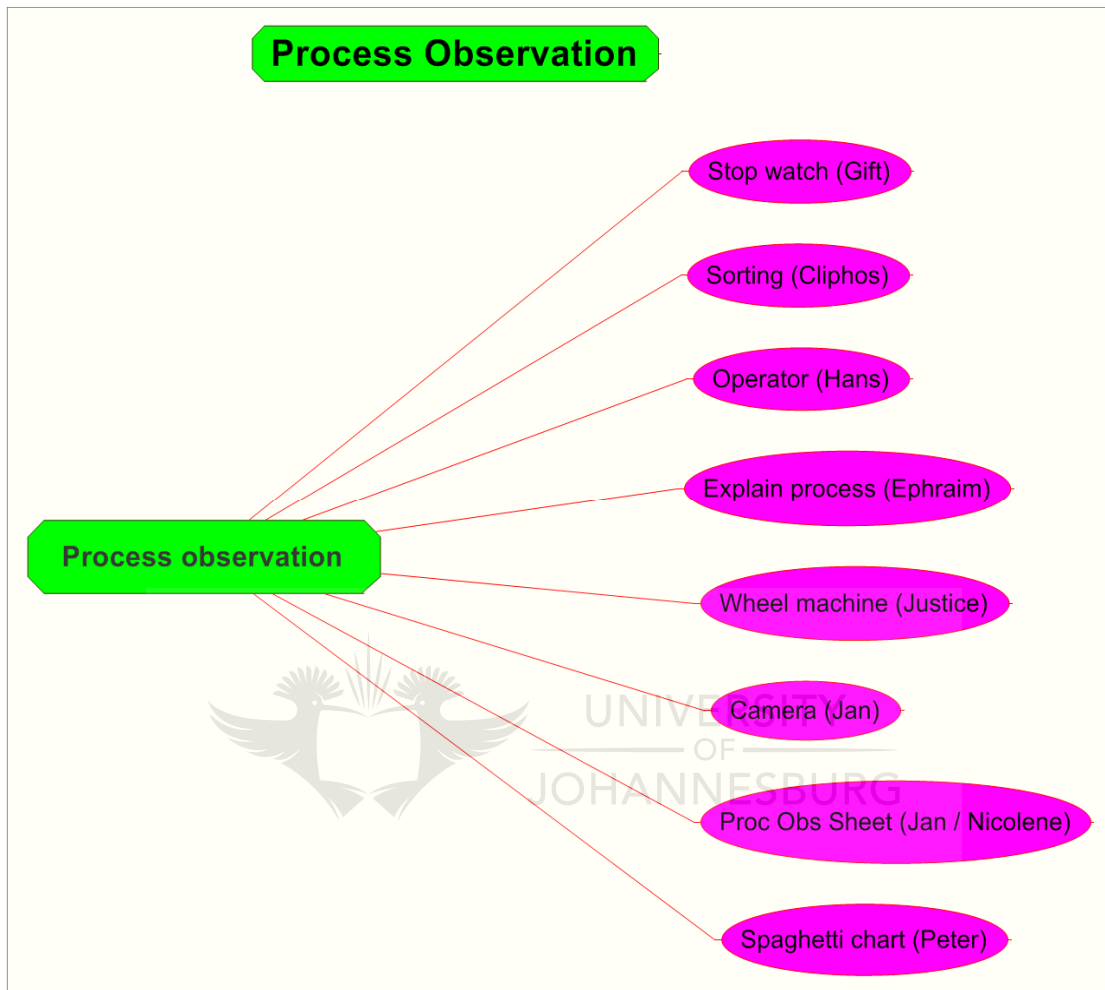
Appendix A: PROCESS MAP




Appendix B: WASTE OBSERVATION FORM

WASTE OBSERVATION SHEET	
Waste Observed During Walk Through Categorized by Type	
1. Movement	
	➤ 4. Move to fill station. 5. Move to empty storage is. Position pallet. 6. Foreman walked to sorting area. 7. Find forklift. 8. Moving to forklift. Foreman goes to fill operator.
2. Wait	
	➤ Waiting for loader. Waiting for sorter. 15. For trucks to be removed. 16. For empty cylinders to be available. Empty cylinders from the customers. 17. Waiting for Forklift.
3. Interruption	
	➤ 18. Looking for loader foreman. 19. Operator searching for foreman. 20. Foreman looking for sorter. 21. Collecting customer. 22. Too many calls from customer services. 23. Stock counting.
4. Searching	
	➤ 1. For orders. 2. For cylinders in empty cylinder bay. 3. For loader Foreman. Searching for fork loader.
5. Inspection	
	➤ 14. Inspect order form.
6. Defects and Rework	
	➤
7. Setup	
	➤ 9. Communicate demand / order to operator. 10. Communicate to loader foreman. 11. Loader Foreman communicates to foreman. Sorter finding the product / cylinders. Communicate to foreman. Communicate to sorter. 12. Sorting / Pallet. Strapping cylinder to pallet. 13. Placing pallet to position.
8. Inventory, Storage and Overproduction	
	➤
9. Unnecessary Processing)	
10. Designs Not Meeting Customer Needs and Unwanted Variety	
11. Hazards Customers enter site and safety on site. Loose cylinders standing on sorting area (whole day). Truck standing on way. Uneven floor in sorting area. Wet surface. Spilled oil. Fire hydrant print hidden by pallet of cylinder. Canopy lying around. Cylinder standing next to the distribution door. Standing on pallets to have a view. Bring empty cylinders to HP fill.	

Appendix C: TEAM MEMBERS PROCESS OBSERVATION FORM



Appendix D: SCOPE DOCUMENTS

<h1 style="margin: 0;">Continuous Improvement Event Scope Document</h1>	
	
Click to see form instructions	
Title of Event Kaizen Manufacturing - Kempton Park - sorting and picking	Date Scope Initiated November 15, 2007
A. Organizational Information <i>(Action Team Lead, Organization Champion, CI Manager)</i>	
Name of Work Group / Organization / Business Unit Packaged Gas	
Industry Group to which it belongs <i>(industrial gas manufacturing, consumer electronics, etc.)</i> Industrial gas manufacturing	
Products / Services provided by this Work Group / Organization / Business Unit industrial gases	
Is there an Action Team Target Means? Why was this event selected to be run? <input type="radio"/> Yes <input checked="" type="radio"/> No Long cycle time and poor layout	
What are the goals the Work Group or Action Team has for improvement? Improve sorting and picking of cylinders	
Does this event align with the goals of the Work Group or Action Team? <input checked="" type="radio"/> Yes <input type="radio"/> No	
What is to be improved? <input checked="" type="radio"/> Work Process <input type="radio"/> Work Area <input type="radio"/> Product <input type="radio"/> Information	
B. Work Process Information <i>(Process Owner, Organization Champion, Action Team Lead)</i>	
Name / Description of the Target Work Process sorting and picking of cylinders	
Who is the manager of this work process? Hein Brink / Shamo Mbonsamy	
Who owns improvements to this work process? Foreman in charge	
How many people and shifts are involved in this work process? Number of People: 6 Number of Shifts: 2	
Locations where this process is performed? (for scoping and replication) Within Target Location: Kempton Park yard Outside Target Location: All PGG Depot	
How often is this process performed? Daily multiple times	

What is the cycle time of this process? ?	Is it possible to observe this process during the event? <input checked="" type="radio"/> Yes <input type="radio"/> No
Which of the following is this associated with? <input checked="" type="radio"/> Global Work Process <input type="radio"/> Global Process Variant <input checked="" type="radio"/> Local Practice <input type="radio"/> Don't Know	In what Region is this process performed? Rest of World
Select all potential SAP impacts by this event: <input type="checkbox"/> Transactional processes may be changed <input type="checkbox"/> Data parameters may be changed <input type="checkbox"/> Data may be optimized	
Which of the following process maps currently exist? <input type="checkbox"/> Extended Value Stream Map (EVSM) <input type="checkbox"/> Value Stream Map (VSM) <input type="checkbox"/> SIPOC <input type="checkbox"/> Sub-Process Map	
What is the role of machinery/equipment in this process? Forklift use pick loads	
C. Problem / Issue Information <i>(Process Owner, Organization Champion, Action Team Lead)</i>	
Who requested this event? Hein Brink / Shamo Mbonsamy	
Is this event the result of another CI Tool application? <input type="radio"/> Yes <input checked="" type="radio"/> No	
What are the perceived issues? Describe the problem.	
<u>Issue</u>	<u>Description</u>
<u>Long cycle time</u>	too much movement
<u>Safety/security concerns</u>	increased fatigue
<u>Employee dissatisfaction</u>	working at a very high pace
<u>Potential future issues</u>	increase in future demand
What is the impact of the perceived issues? increased movement, search time, unorganised layout and a safety issue	
What are the key customer concerns? What are the <u>Customer Critical Requirements</u> (CCRs)? Internal Customers: identifying the correct person to perform the task External Customers: right product, right time and right place	
What forms of waste exist?	
<u>Form of Waste</u>	<u>Description</u>
<u>Motion</u>	rolling cylinders to pallets
<u>Defects / Rework</u>	replacing faulty cylinders
<u>Searching</u>	searching for correct cylinders
<u>Setup</u>	preparing a full pallet

<u>Interruptions</u>	unavailability of forklift / receiving a pallet with different products
<u>Waiting</u>	Waiting for cylinders to be available
How long have these issues existed? for ever	How often do these issues occur? daily basis
Estimate the current rate of occurrence: <input checked="" type="radio"/> Increasing <input type="radio"/> Decreasing <input type="radio"/> Constant <input type="radio"/> Don't Know	
What is the cost impact of the current rate of occurrence? 	
What are the potential causes of the issues?	
<u>Category</u>	<u>Description</u>
<u>Methods</u>	Cylinders are rolled one by one into pallets
<u>Equipment/Systems</u>	unavailability of forklift and kanban system
<u>Materials/Inputs</u>	Unavailability of empty cylinders to make a full pallet
How much does human error contribute to causing the issues? <input type="radio"/> A lot <input checked="" type="radio"/> A little <input type="radio"/> None <input type="radio"/> Don't know	
<i>An ACE analysis can be used to help determine potential causes.</i>	
What solutions have been tried to date? What impact have those solutions had? Putting visual controls. People turned back to the old way of doing things	
What results do key stakeholders expect from this event?	
<u>Stakeholder</u>	<u>Expectations</u>
<u>Customer - External</u>	Right product, right time and right place
<u>Customer - Internal</u>	Not to interrupted during production
<u>Employees</u>	Working smart and effectively
<u>Management</u>	Reduction of waste in work process and elimination of safety issues
<u>Shareholder</u>	Increase output with increased returns and cost reduction
What measures will this event affect?	
<u>Employee Satisfaction</u>	Is this measure currently being tracked? <input checked="" type="radio"/> Yes <input type="radio"/> No
What is the target? 20%	How is it being tracked? through interviews
	What is the current performance of this measure? 11%
What additional data should be collected in order to understand baseline performance? Customer order and expected delivery	
Which of the following compliance issues are associated with this data? <input type="checkbox"/> <u>Sarbanes-Oxley Act</u> (SOX) <input type="checkbox"/> Code <input checked="" type="checkbox"/> Regulatory Products segregation	
D. Confirm the Improvement Technique <i>(Process Owner with Tool Expert/Facilitator)</i>	
What scope is to be included in this event? <i>(Locations, regions, process boundaries/start & stop points, process variations, etc.)</i> Kempton Park, Gauteng. sorting cylinders into pallets, and move to storage area	
How much time is available to run this event? 5 days	
By when do the resulting improvements need to be implemented and/or benefits realized? End December 2007	
What is the allowable budget for this event? 	
Which <u>tool/technique</u> is to be employed in this event?	

Primary: <u>Manufacturing Kaizen</u>				
Secondary: <u>WOVC</u>				
E. General Tool/Technique Information (Process Owner, Org Champ, Tool Expert/Facilitator)				
What roles or functions (Subject Matter Experts) should participate in this event?				
Core Team: <u>Foreman, operator and cylinder sorter</u>		Time Commitment: <u>Total event</u>		
Consult: <u>Local management</u>		Time Commitment: <u>when needed</u>		
Select the currency you will measure costs and benefits in: <u>Other</u> R				
Estimate the <u>costs</u> of the event:		Estimate the <u>benefits</u> of the event:		
Labor: <input type="text"/>		General: <u>Good plant layout</u>		
Materials: <input type="text"/>		<u>Effective labour utilisation</u>		
Travel: <input type="text"/> 0.00		<u>Reduction of waste, i.e, movement, searching</u>		
Other: <input type="text"/> 0.00		<u>Employee job satisfaction</u>		
Total = <input type="text"/> 0.00		Hard: <input type="text"/> 146,550.00		
		Soft: <input type="text"/> 2,322.00		
		Total = <input type="text"/> 148,872.00		
What conditions and limitations does the team need to be aware of?				
Do:		Do Not:		
<ul style="list-style-type: none"> • Wear PPE • Minimise impact on daily production • Ensure communication with all relevant people • Use MOC process for any changes 		<ul style="list-style-type: none"> • 		
Is the team empowered to implement improvements identified during the event?				
<input checked="" type="radio"/> Yes <input type="radio"/> No		Explain: <u>time permitted can follow up with action plan</u>		
Are there potential <u>patent / copyright / licensing</u> opportunities that may result from this event?				
<input checked="" type="radio"/> Yes <input type="radio"/> No <input type="radio"/> Maybe		Explain: <u>ACE</u>		
<i>Be sure to follow up after the event to make sure any potential patent opportunities are pursued.</i>				
F. Decision to Move Forward with Event as Planned (Org Champ with Tool Expert/Facilitator)				
Should any other tools be applied before running this Manufacturing Kaizen event?				
<input checked="" type="radio"/> Yes <input type="radio"/> No				
What barriers to change exist at this location?				
<u>People not aware of the impact of CI</u>				
Who are the key stakeholders of this event?				
Stakeholder	Event Responsibility	Name	Email	Telephone
Event Requestor		Hein Brink / Shamo Moonsamy	brinkh@apsap.co.za	0119776456
Event Coordinator	Coordinate event preparation and logistics.			
Scope Information Provider	Provide detailed event scope information to Event Facilitator.			
Manager of the Target Process		Hein Brink / Shamo Moonsamy		
Manager of the Target Process				
Process Owner		Foreman		
Event Follow-Up Champion	Communicate event results, manage improvement implementation, follow up on action items, and track measures.	Gift Nhlabathi		

CI Manager		Gift Nhlabathi		
CI Organization Champion		Gift Nhlabathi		
CI Action Team Lead	Ensure event links to Action Team goals and objectives.			
Work standards contact (ISO, QMS)	Review and approve changes to work process (if applicable).	Barry Little		
Organizational Safety Contact	Review and approve safety-related improvements.	Rushda Thomas		

Should others review and approve this scope document prior to conducting this event?

Yes No

G. Agreement to Hold Event as Planned Above

Role	Name	Signature	Approved?	Date
Manager/Supervisor	Josua Leroux		<input checked="" type="checkbox"/>	December 06, 2007
Manager/Supervisor	Hein Brink		<input checked="" type="checkbox"/>	December 06, 2007

H. Event Details (Action Team Lead, Org Champ)

Dates of Event:	Host Site Name:	Site Contact Person:
Start: December 10, 2007	Kempton Park	Hein Brink
End: December 14, 2007	Address:	Phone #1:
	Cnr Plane & Prett Road, Spartan Ext 1 Private Bag X02 Kempton Park 1620	Phone #2:
		Fax #:
		Email:

Are there any safety concerns a visitor should be aware of?

Yes No

Wear PPE

Must personal protective equipment be worn or safety procedures learned to visit this workplace?

Yes No

(Attach descriptive information should the list be extensive)

PPE/Procedure	Provided by site?	Comments
<input checked="" type="checkbox"/> Safety glasses	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/> Work gloves	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/> Safety shoes	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/> Metatarsal protection	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/> Hard hat	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/> Nomex clothes	<input checked="" type="checkbox"/>	
<input type="checkbox"/> Other equipment	<input type="checkbox"/>	
<input checked="" type="checkbox"/> Safety orientation	<input checked="" type="checkbox"/>	

Attach List? Yes No

Team Members

Name	Organization	Function/Role	Email	Telephone
Gift Nhlabathi	AP South Africa	Event Leader	nhlabatg@apsap.co.za	0119776483
Jan Robberts	AP South Africa	Co Leader	robberts@apsap.co.za	

Will any team members be traveling for this event? Yes No

List a minimum of 2 people who can provide tool-specific coaching during this event:
(Be sure to contact these people before the event to determine availability)

<u>Name</u>	<u>Organization</u>	<u>Email</u>	<u>Telephone</u>	<u>Availability</u>
Peter Vera	APSAP			
Jan Robberts	APSAP			

Event Pre-Work: Information Needed

Identify information required for team activity, to be gathered before the event:

<u>Information</u>	<u>Comments</u>	<u>Who Will Gather?</u>
<u>Process Map</u>	To see what is done	Gift Nhlabathi
<u>Current Forms Used</u>	To see required documentation	Gift Nhlabathi
<u>Pictures</u>	For before and after event	Justice Siala



Appendix E: ACTION PLAN TEMPLATE

From Brainstorming Idea (C& E)	Person Responsible (WHO)	Scheduled Completion Date (WHEN)	Completion Date (STATUS)	Follow-up	Remarks
Establish a lower minimum purge pressure.					
Reduce the level to which cylinders need to be vacuumed					
Hook unused vacuum pump in tandem to current vacuum pump to speed vacuum and purge					
Install hand wheels on pigtails of the prep manifold to speed hook-up of cylinders.					
Have storage bins for each type of cylinder valve adapter mounted on manifold.					
Replace wrenches used in hook-up operations and have a separate set for prep area.					
Organize cylinders in storage area by expiration date					
Shift preparation of 296 Ar/O ₂ to blending area.					
Place trip protector over exposed line from computer network to printer.					
Counsel worker on use of earplugs.					
A inbox tray to be placed on the foreman's desk for demand orders only.					
Design new layout at the empty cylinder bay area.					
Create a no parking area in front of the empty cylinder bay					
Two way radios to be introduced to improve communication.					
Allocate a fork lift only for HP fill					
Allocate a specific area for trucks to park. Use the customer co-ordinator to					
Implement visual signs in the empty cylinder bay					
Convert unused N ₂ cylinders to CO ₂ cylinders					
Out of date cylinder to routed to maintenance department by the customer co-ordinator					

Appendix F: MANUFACTURING KAIZEN CERTIFICATE

