IMPACT OF LEAN MANUFACTURING PRACTICES AND OPERATIONAL PERFORMANCE OF BEER BREWING PROCESS: A CASE STUDY OF KENYA BREWERIES LIMITED

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DECLARATION

I declare that this research project is my original work and has not been submitted to any other university for assessment or award of degree.

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Declaration by the Supervisor

This Research project has been submitted for examination with my approval as University Supervisor.

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DEDICATION

This research project is dedicated to my sons Belyn Gweth and Benjamin Owiny for their understanding during this period of study.

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I wish to sincerely give my appreciation and gratitude to my supervisor Mr. Tom. Kongere and moderator Mrs. Zipporah Kiruthu for their enormous support, timeless dedication and wisdom in ensuring that I am well equipped with the knowledge and skills to confidently carry out the research project. May God bless you all.

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ABBREVIATIONS ACRONYMS

ATO	Assemble To Order
ETO	Engineering To Order
EABL	East African Breweries Limited
EAML	East African Maltings Limited
FG	Finished Goods
JIT	Just In Time
KBL	Kenya Breweries Limited
LM	lean Manufacturing
MTS	Make To Stock
MTO	Make To Order
MSC	Mumias Sugar Company
RM	Raw Material
SBL	Serengeti Breweries Limited
TOC	Theory of Constraint
TPM	Total Productive Maintenance
TQM	Total Quality Management
WIP	Work in Process
UK	United Kingdom
UDV	United Distillers Vinters
UBL	Uganda Breweries Limited
CMMS	Computerized Maintenance Management System
IPQI	In process Quality Index
PDSA	Plan Do Study Act
RCPS	Root Cause Problem Solving

ABSTRACT

The main objective of lean manufacturing is to create more value for customer by eliminating non-value adding activities. Manufacturers throughout industries are adapting the lean manufacturing system of production to remain competitive globally. This study was seeking to establish the impact of practices of lean manufacturing practices and operational performance of beer brewing process at Kenya Breweries Limited. The methodology of research adapted was descriptive case study using Kenya Breweries Limited as a case study unit. Interview guide was used to collect data after which content analysis was used for the collected data analysis. The impact of LM practices and operational performance of beer brewing process was cited to be highly above average for Total Quality Management, Total Productive Maintenance and Poka Yoke. Just-In-Time and 5s were cited to be averagely adapted. The findings revealed that the quality of beer has increased resulting into increase in flexibility of beer volume and also flexibility of producing different beer brands. There has been reduction on waste generated during the beer processing like; Inventory of raw materials, operator's movement, brewing time for one batch of beer and customer delivery time. The findings also revealed an increase in overall equipment effectiveness (OEE). OEE as a tool for measuring performance indicates areas of process improvement by measuring different types of production losses. In summary the findings indicate that all the lean manufacturing practices are in one way related to operational performance. Kenya Breweries Limited realizes the full benefit of having adapted the full implementation of lean manufacturing practices.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Today's fiercely competition in the market, has made organizations realize that the concept of traditional mass production has to be integrated with new ideas .New ideas which will propel any organization to face global competition. The focus of many organizations as pointed out by Muhamad et al. (2012), has been on cost reduction, increase in operational efficiency, improving levels of quality, maximizing profits and satisfying customer needs. Performance of any manufacturing company is greatly affected by the type of manufacturing practices adopted.

To compete, businesses must view customers and competitors in global terms, in order for them to remain globally relevant. Under competitive, regulatory and community pressure, it has become very important for organizations to balance between environmental performance and economics Zhu and Sarkis (2004).These organizations have been on pressure to improve all aspects of operational performance, customer response time ,flexibility and quality, as well as reduce cost of production. Managing processes has been a benchmark for competition on the basis of quality, time and technological advantage. Quality is defined as the product perception from the customer's side. Without quality products, an organization loses its ability to compete in the market place. Its cost of production increases and become uncompetitive (because of scrap, rework and warranty cost). Xu and Beamon (2006) states that co-ordination of activities is critically important to achieve waste reduction.

Waste has to be managed if not eliminated in order to produce quality products, hence profit. Profit maximization are only for organizations who try to manage their operations and systems in reducing waste and producing quality products. These

organizations do employ new ideas and strategies in their systems of operations. Lean manufacturing is one of these new ideas that major organizations have been trying to adopt for them to remain relevant in the global market competition. Japanese manufacturers after World War II, had shortages of human resources and materials. These shortages gave birth to " Lean " manufacturing concept Womack et.al.,(1998) .According to Zayko (1997), the result of lean manufacturing is a 50% reduction of tool investment, space for manufacturing, human effort and time of product development, and an increase from 200% to 500% of quality improvement creating more efficient workflows.

Lean manufacturing is being responsive to change, putting more focus on quality and value addition by waste elimination Liker (2004). According to Czarneeki and Loyd (1998), it is an approach of mapping and waste eliminating through continuous improvement by quality deployment function in pursuit of perfection. Companies that aspire compete effectively in the local as well as the global market should be superior in products manufacturing within the least possible cost to achieve excellence in quality and price.

Common lean tools according to Monden, (1998), Feld,(2000) and Nahmias, (2001) are: 5S focusing on effective work organization and standardized work procedures. Total quality management (TQM), a continuous improvement practice, which involves employees and problem solving teams. Total preventive maintenance (TPM), where regular maintenance is carried out by employees, on their equipment and machines of use to detect any anomalies. Just–in–time (JIT), this is a system where demand is initiated by the customers, then the demand taken backwards to raw material. JIT system employs quality function deployment in product manufacturing.

The benefit of lean manufacturing seems to be outstanding in terms of gains in profit, quality production and global competition, yet problems can arise even after a lean system has long been operational. This study will examine the impacts and challenges in implementing lean manufacturing in operational processes particularly beer brewing processes at Kenya Breweries Limited.

1.1.1 Lean Manufacturing Practices

Lean manufacturing is a comprehensive set of practices that when matured and put together, will reduce and eliminate waste. Lewis ,(2000) and Chase, (2006) conclude that lean manufacturing is a set of integrated practices designed to achieve a high production volume, using the right quantity of inventories of raw materials, work in process and finished goods. Sakakibora (1997) associates lean practice with high performance in world - class manufacturing. Schonberger (1982), White (1999) reviewed related research lean production and came up with benefits such as: labor production and quality improvement, decrease in customer lead time, cycle time and manufacturing cost. Lean manufacturing practices are operational systems that are designed to create efficiency in manufacturing processes by taking a total systems perspective. It is a means of making consistency in methods and tasks, equipments, organization at workplace and work output, through the foundation of operational stability.

Womack and Jones (1998), points that a lean production system as an integrated system of manufacturing requires implementation of different LM practices. Womack and Jones (1998), further suggests that the implementation of these practices can give in higher operational performance. For example, reduction in work - in process inventory, links to human resource capability by empowering teams to be able to

solving problems. Thus the problem solving ability can help teams improve on their skills of identifying the root courses of quality problems which help to improve workflow and equipment efficiency improvement. The main lean manufacturing activities are JIT, TPM, TQM, Continuous Improvement and Poka Yoke.

Total Productive Maintenance (TPM) maximizes equipment effectiveness by use of planned predictive and preventive maintenance of the equipment and using current techniques of maintenance optimization. Nakajima (1989) established that TPM can reduce inventory, lead time and random machine breakdowns. TPM is measured in terms of overall equipment effectiveness (OEE) increase, as a function of other production losses and downtime.

Cua (2001) emphasizes that maintenance reflects on new process equipment or technology. TQM relates to products quality sustainability by continuous improvement and process that is centred on the needs of the customers. Practices of TQM include measurement capability (statistical methods), programs of quality management, formal programs of continuous improvement and process capability.

According to Abdulmalek and Rajgopal (2006) Just-In-Time (JIT) is a system where the demand is initiated by the customer. The demand is then channeled backwards from the final assembly all the way to raw material, thus "pulling" all requirements just when they are needed. Harrison and Van Hoek (2008) established that the origin of JIT was from the inventory holding concept of reduction, which requires that components and parts to be delivered only when they are required for production and not before.

JIT relates to all practices related to production flow. Sugimori (1977) defines JIT as a program for manufacturing whose goal is waste elimination by continuous

improvement. JIT has impact on two forms of wastes: Work-in -Process inventory and unwarranted flow time delays. Both wastes are reduced by implementing LM practices related to production flow such as reduction in cycle time, reduction in lot size, reduction in changeover practices to reduce work in process inventory and by cellular layout implementation, reengineering of production process and removal of constraints or bottleneck to mitigate unnecessary production delays . Abdulmalek and Rajgopal (2006), concludes that machine operators should be part of maintenance and monitoring team to be able to prevent and provide warnings of machine malfunctions because they are closest to machines .Carrying out regular equipment maintenance is the responsibility of the machine operator in order to identify any fault and tag it, Since the focus shifted from fixing breakdowns to preventing breakdowns

1.1.2 Operational Performance

Operational performance is the efficiency and effectiveness an organization transforms its input into output. Schmenner and Volmann (1994), Clinton and Chen (1998), established that to be able to compete globally organizations must be able to re-orient their manufacturing processes and be able to measure their performance. Benchmarking practices aimed at adopting manufacturing excellence cannot generate better results if organizations lack the capacity to understand and measure their performance.

According to Voss (1997), operational performance is an organization's process parameter that is measurable. Operational performance is measured as a compound of various dimensions of performance (cost, quality, flexibility and delivery). Companies that focus on performance results in adopting LM as a measure of performance improvement strategy. Shah and Ward (2003) established that by the implementation of lean manufacturing practices, namely: TPM, TQM and JIT, operational

performance too is influenced. The bundles of LM practices have different effects on performance. Cue (2001), tested the awareness of performance while Shah and Ward (2003) tested the awareness of "improvement" in performance. The impact of lean manufacturing on organizational performance of manufacturing organizations is a measure of effectiveness.

1.1.3 Kenya Breweries Limited

Kenya Breweries Limited (KBL) was founded by two white settlers, George and Charles Hurst in 1922. According to EPZA Report (2005), consumption of bottled beer in 1947 was only for the whites during post-colonial era. KBL was registered as a public company in 1934. KBL core business is manufacturing, packaging and marketing of alcoholic and non- alcoholic beverages like Tusker, pilsner, tusker malt, Guinness, allsopps, senator keg, whitecap, Alvaro (www.eabl.com), Accessed on 20/7/2016.

Excellent and proficiency in customer value management, is a solid proof of their commitment to be the number one market leader in beer industry. These attributes has positioned KBL to increase the scope of its customer's solutions and services. KBL as one of the subsidiaries of EABL is the biggest in terms of plant size hence producing almost eight alcoholic brands in the same unit compared to the other two which produce at most four brands and sometimes seek support from KBL. KBL then has different lines of beer production in order to satisfy the high demand of different beer brands both in local and global markets. Kenya being the headquarter EABL plus the above attributes of KBL makes it a site worth studying, hence the rest of the study will put more emphasis on KBL. (www.eabl.com), Accessed on 20/7/2016.

Kenya Breweries Limited can practice lean manufacturing practices in beer brewing process to become a competitive strategic tool to improve and maintain the competitive image of the organization. Brewing department can utilize lean methods to increase efficiency and improve quality by eliminating waste. These wastes include waste generated from energy usage (steam, and electricity) and the extract wastes. Beer brewing is the manufacturing of alcoholic drink (beer). According to Vrellas and Tsiotras, (2014), brewing is based on three major biochemical changes: conversion of starch to sugars; during fermentation conversion of sugar in presence of yeast to alcohol, carbon dioxide and heat; cold storage and maturation where stabilization takes place. During production, beer production passes three chemical and biochemical reactions (mashing, boiling, fermentation and maturation) and three solid-liquid separations (wort separation, wort clarification and beer clarification). During the process of beer brewing, water used during brewing, wastewater and liqids-solid separation form a real economic opportunity for improvements in beer brewing process.

In implementing the lean principles, its benefits seem to be outstanding, according to Zakyo, (1997), that quality can improve from 200% to 500% and a 50% reduction on the other wastes, yet problems can arise even after the system has long been operational. The impacts are on the human side of lean production as well as on the product side during beer processing. While waste removal should not be the focus of any lean practice, it is actually achieved while seeking to implement the principles of lean manufacturing.

1.2 Research Problem

Lean manufacturing focuses on customer value creation, by eliminating activities that adds no value in producing high quality products. Motwani, (2003) emphasizes that lean manufacturing is a business practice, which focuses on systematically identifying and eliminating process wastes, which involves, improving and changing processes, while meeting the customer's needs in terms of good product quality at the lowest cost quality and by delivering quality products to the manufacturer.

Kenya Breweries Limited core business is of manufacturing, marketing and selling of alcoholic and non-alcoholic beverages like Tusker, Guinness, pilsner, Alvaro among others (www.eabl.com), Accessed on 20/7/2016.

During beer processing all the value added activities that result into beer production in order to improve the business profitability are embraced positively because of the positive impact they have on the business. On the other hand the effects of the muda (waste) which are usually not clearly visible are also felt. There has been both positive outcome and challenges experienced in employing the lean methodologies in eliminating waste during beer processing.

The effect of lean manufacturing having been addressed by a number of researchers. El-Namrouty and AbuShaaban, (2013), found that lean manufacturing affects positively on cost reduction of Gaza strip for the manufacturing business , touched on the general manufacturing industries instead of individual or a group of process industries. Different process industries have different transformation systems. Fillaudeau, Blanpain and Daufin (2005), concluded that water consumption, waste water and waste management remain a critical and practical problem. In the study no single application of lean technique was involved and mentioned. Koroneos,

Roumbas, Gabari, Papagiannidou and Moussiopoulos (2003), performed a beer production life cycle analysis to the total impact to the environmental and obtained that production of bottles followed by packaging and beer brewing are the subsystems that contribute mostly to the adverse environmental impacts of the beer production .Fakoya and Margaretha Van der Poll (2012) concluded that integrating Enterprise Resource Programme (ERP) and Material Flow Cost Accounting systems will give the sufficient information on the cost of waste. Vrellas, et.al. (2013) found that lean production alone cannot under statistical control bring a process under it and so can six sigma alone in speed improvement of a process, hence the combination of the two to form Lean Six Sigma.

Through studying the relationship between Business Process Re-engineering and Organizational performance for EABL, Gitagama (2008) established that EABL had actually benefited a lot from Re-engineering, through growth in efficiencies which led to improved growth as it was measured by the profitability over the years. In studying strategies adapted by EABL in enhancing sustainable competitiveness in Kenya, Ngothi (2015), established that by EABL adopting competitive strategies like, effective corporate social responsibility, continuous innovation, cost leadership and product differentiation, EABL managed to sustain competitiveness.

Kiplagat and Noor (2015) found that organization policy on Just-In-Time implementation affected supply chain performance at EABL. Karanja and Wagoki (2014), on material sourcing found that communication to be shared among supply chain partners in building trust and understanding between the buyer and the supplier hence good buyer supplier relationship. From the above lean manufacturing studies analysis, no single study was done on waste during beer processing and in particular

beer processing at Kenya Breweries Limited. This is the gap the study seeks to fill, by seeking to answer the question;

What is the impact of lean manufacturing practices and operational performance of beer brewing process at Kenya Breweries Limited?

1.3 Research Objectives

The main objective is to study the impact of lean manufacturing practices and operational performance of beer brewing process with respect to waste elimination. The specific objectives of the study are;

1. To establish the extent of lean manufacturing practices and operational performance employed in beer brewing process at Kenya Breweries Limited.
2. To establish the impact of lean manufacturing practices and operational performance during brewing at Kenya Breweries Limited.

1.4 Value of the Study

The findings of the study will be used by future researchers and academicians in areas of lean manufacturing and operational performance of beer processing and add to the existing body of brewing knowledge. From the inferred conclusions, the study will also open up areas for further research.

The study will assist the KBL brewers in understanding the impact of eliminating different wastes during beer processing. This will give them a new approach and strategies in waste elimination, depending on the severity.

The study will assist UBL and SBL in improving their beer operations by implementing the findings and recommendations made for KBL.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Information on topics related to the research problem are provided for in this chapter. Various authors have written on the concept of lean manufacturing and operational performance which the study sought to examine. It covers on: theoretical reviews, empirical studies, summary of the studies and knowledge gap portrayed by the reviewed literature and conceptual framework.

2.2 Theoretical Literature Review

According to Bull, (1991), a theory is a set of ideas, definitions, and statements that present a structured view of phenomena by identifying relationships among variables with the purpose of predicting or expounding the phenomena. The theoretical foundations for this study are informed by the theory of constraint, and the theory of production as explained below.

2.2.1 Theory of Constraints

The Theory of Constraint and lean manufacturing practices are both systematic methods of operational performance improvement of an organization. Moore and Scheinkopf, (1998) introduced the Theory of Constraints (TOC) which provides focus in the world of more information, in the landmark book, "The Goal". It is a guide for practitioners in improving their organizations by focusing on the constraints to enjoying profitability. TOC looks organizations as systems with resources linked by the processes they perform. A system contains a constraint, which is anything that hinders the system from achieving higher performance comparable to its purpose.

Goldratt, (1992) further describes TOC as a method of identifying the biggest limiting factor (the Constraint), that acts as a blocker in achieving a goal and systematically improving the constraint until it is no longer a blocking factor. TOC 5-steps gives focus and systematic approach for organizations to use to successfully follow the ongoing improvements, these are; establishing the system's constraints, decision making on how to exploit the system's constraints, raising the system's constraints, and stopping an element like inertia to become the system's constraint .Breaking a constraint means going back to the drawing board again to step one. TOC and LM have some similarities as Goldratts (1992) established. TOC and LM are both methods which offer focused and systematic processes, used by organizations in pursuing successfully the ongoing improvement. Both TOC and Lean embrace the fact that value of a product/service is derived from the customer's perception of value. Beer productions consist of stages, milling, mashing and boiling. The main goal of milling, mashing and boiling of barley is to produce quality beer. For a batch of beer to be produced in right quantity within the right quality, all the stages have their specific time of processing and passes to the next stage hence any blocker that might inhibit the forward process at any stage by exceeding the required time to process then becomes the constraint and the operator has to work through the constraint to get beer as the end result.

2.2.2 Production Theory

Production theory is traced back to the post war period, according to Ohno,(1988), Toyota Production System was developed by Taiichi Ohno who is an advocate powerful for "Leanness" Womack et al., (1990) defines lean product as "lean", as the pioneers put their opinions forward , because it uses " Less of resources, even as little as half " Half of the human resource effort in the factory, half of the space for

manufacturing , half of the tools investment and half of the time in hours the engineering department uses to develop a new product. Womack, (1990), Oliver and Wilkinson, (1992) state that System of Toyota Production gives centrally to kaizen concept or continuous improvement. Improvement in removing waste (muda-in-Japanese) activities which do not add value. Monden, (1994) define the concept of muda as set-up time in excess, excessive inventory storage and work in process, defects in finished good requiring rework or repair, overproduction, unnecessary motion, over processing and idle time. Womack and Jones, (1996). Henderson and Larco, (2003) describes waste as any tangible or intangible process or product, that adds no value to the end product. The seven waste of lean were originally categorized by Taiichi Ohno (1988), as a pioneer of the Toyota Production System. He separated the waste he saw into seven categories, which made them easier to identify and eliminate. The wastes of Lean are: Transportation, Inventory, Motion. Waiting, Over-production, over processing, defects and Human skills. Toyota Company later developed lean manufacturing benchmark. According to Ohno (1978), the benchmark was embodied by the Toyota Production Systems, whose goal was cost reduction by waste eliminating using two methods like; Just-in-time and automation with a human touch as Toyota Production System the main pillars.

In beer brewing (production) which is a continuous process, starts with milling, mashing and boiling within prescribed time limit to achieve the right quality of beer produced. Each brewing stage is linked to the former stage and any time delay due to unforeseen circumstances, will affect the quality of beer produced hence waste will be generated. Beer is brewed according to the market demand which also will dictate the amount of raw materials (inventory) needed for the process to produce the best quality and volume, within the time demanded by the market.

2.3 Lean Manufacturing Practices

There are different types of lean practices that can be done under LM. Shah and Ward, (2003), developed a list of four different bundles practiced under lean manufacturing, which include: JIT, TQM, TPM and HRM. When grouped together JIT, TQM and TPM have same goals of waste elimination through continuous improvement.

According to Paneru, (2011) JIT is possessing the right items, of the right quality and quantity at the correct place, within the exact time needed. According to weekly beer brewing plan, which is further divided to 24hours brewing plan, sorghum, barley, wheat and other raw materials needed to meet the plan need to be at the KBL warehouse and silos in time for Milling to start, followed by the subsequent brewing processes. This addresses waste like: work-in-process inventory and flow time delay unnecessarily during beer production (waiting).The wastes will have an impact on the cost of inventory, Timeline of beer production which affects the performance and delivery of the process.

Total Quality Management (TQM) according to Sharma (2012) is an approach of quality improvement by continuous improvement of goods and services through of all processes, production without defects, quality driven by customer, and focus on improvement. From Milling to Wort cooling process, quality is embedded in the process. Beer brewing is a continuous timed process, where boiling and mashing depends on the milling process, hence when quality is compromised at the milling stage, then quality will fail at the mashing and boiling hence the whole batch will be of poor quality. TQM eliminates the waste of defect, which is poor quality of beer

produced which may result to rework. Rework has an effect on cost and quality of beer and affects also the production timelines.

5S Principles (Housekeeping) which is an indispensable ingredient of good arrangement . Sharma (2012) established that through good housekeeping employees get to discipline themselves an maintain good working environment .From Milling to wort cooling processes, quality is paramount at every stage. To avoid contamination, housekeeping is mandatory or else the quality of beer (especially Flavors) will be distorted as yeast which are key in beer conversion and sensitive to contaminations are involved. Safety is also another principle added to 5S to make 6S. Food (beer) safety ensures good beer hygiene. Employee Health and Safety ensure the brewing employees have good health while working, creating a safe working environment. The 6S eliminates the wastes of: defect on beer which has an impact on quality, employee motion which has an impact on performance and timelines.

Total Productive Maintenance measures the overall equipment effectiveness (OEE), which has a relationship with the machines breakdown time and other production losses according to Nakajima, (1989). Each of the beer brewing process has machines designed for that process. To meet the weekly plan of production, the process (machines) has to run 24hours a day in 7 days without stoppages due to machine breakdowns. Maintenance of machines is paramount to smooth process run hence increase in productivity and assurance of quality. TPM aims is to maximize the efficiency of brewing process machines, matching the brewing practices with different set of tools and techniques applicable at all stages. TPM eliminates the waste of waiting (both machine and employees) improves machine performance and quality of beer produced. TPM has a direct impact on timelines, beer quality and cost (machine breakdown and beer rework).

2.4 Operational performance

Voss (1997) defines operational performance as an organization's process that is being measured. Operational performance consists of mainly: Process equipment's reliability and defects rate, cycle time of production, in time delivery, quality cost and scrap reduction. Birech (2011) established various measures of performance within operational area like, individual performance measure, which include: quality measures, productivity measures, inventory measure, lead-time measures, and preventive-maintenance measures. According to Bou and Belton (2005),Shah and Ward (2003), TQM reduces process variance which makes the manufacturing process simple and closely matches customer demand and production, while JIT has an impact on quality management by reducing lot sizes hence decreasing waste potential and rework. Elisa (2013) established that those organizations that have adopted the TQM approach have shown to be positively associated with general performance improvement with higher operation efficiency and improved financial results.

Nakajima (1988) launched TPM concept which provided a quantitative metric called overall equipment effectiveness. OEE is a measuring tool that measures performances of different types of production losses and highlights areas of process improvement. Fleischer (2006) established that competition of manufacturing organizations largely needs the reliability and throughput of their production facilities.

The above three bundles are positively related to operational performance measured through items like: scrap and rework costs, and manufacturing cycle time.

2.5 Empirical studies

Studies have shown the application of lean manufacturing widely. Julien and Tjahjono, (2009), did a study at Safari Park Buckinghamshire UK on implementation of lean thinking, to enable profit increase through waste elimination and improving the key processes' efficiency while satisfying the needs of the customer. With the changing economies, customer's demand for services and leisure products do fluctuate just like other non-essential house hold commodities. The Park being a service industry, Julien established the staff had to fully understand the park processes throughout and their relationships, for accurate to information flow at the right time to customers. They noted that Mapping processes and Value Stream increase the understanding of the expectations of the internal customers. When staff understands the external customer's Value stream, it helps them internally on how to help themselves in providing better services hence team work. Julien and Tjahjono, (2009) concludes that when staff are involved in the lean implementation, their satisfaction increases, hence ownership.

Demeter and Matyusz, (2011), studied the inventory turnover impact of lean practices. They found that firms that had adopted the lean practices have no inventory being held for long compared to that do not practice lean manufacturing. They also find out that factors like: (systems of production, order types, product types do influence the inventory turnover of lean manufacturers. They found that different types of inventories are sensitive to different factors above. Production system strongly affects Work in process (WIP), while the type of order affects raw material (RM) and finished goods (FG). Line production system (cellular or dedicated line) being used by lean practicing companies have a higher inventory turnover is dedicated line). Lean companies have made to order (MTO) and assemble to order (ATO)

processes have higher inventory turnover than engineering to order (ETO) or make to stock (MTS).

Worley and Doleen, (2006) in the study of the support of management and communication role in support of implementation of lean manufacturing, they established that the support of management do play a very important role in communicating the lean manufacturing implementation practices. Management support has an impact on LM practices implementation either negatively or positively depending on the attitude of the management. The study also found that improved communication was as a result of support for lean implementation in the organization by the management.

Modi, Hong and Yang, (2010) studied managing business performance environment with respect to the impact of lean manufacturing. They found that management practices on business environmental became very important variable in resolving the conflict between business environmental performance and lean practices. It was further established that lean manufacturing practices and environmental management practices in business are distinct and impact differently on business performance outcome, understanding the performance impacts of managing environment is important in light of the conflict between environment and economic objectives**,** the study was conducted for manufacturing firms.

Malonza, (2014) in his study seeking to establish the effect of lean practices and operational performance of Mumias Sugar Company Limited Kenya (MSC), established that lean manufacturing practices had a constructive quality effect on operational performance. Through improved operational performance, there was reduction on waste, improved efficiency and reduced lead times between the

processes. Tourki, (2010), states that organizations that adopted lean manufacturing, have an advantage over the others to survive in the global competitive environment. Malonza further established the main challenges that faced Mumias Sugar Company Limited as lack of support from the top management and resistant to culture change. Malonza noted that MSC had not fully implemented lean manufacturing practices with some of the practices employed noted as below average.

Maina, (2013) in the study of food companies in Nairobi that are implementing lean management practices, found that organizations that adopted lean manufacturing enjoyed the benefits associated with it, like improved operational performance by reducing and eliminating waste in some instances. He further established also that, throughput increased, quality improved, flow line increasing and scaling down in work-in-process as expected to build -to schedule. He concluded that most organizations have not fully embraced and implemented the lean practices, hence not fully enjoying the benefits of lean manufacturing.

Sumo, (2015) in the study of lean practices and supply chain performance among automobile assembling in Kenya, found that reduced inventory, reduced manufacturing costs, waste reduction and short setup time are the aspect of Just-in -time which are important to supply chain performance. The study also found that reduced cost of information processing and transmission were significant to influencing the performance of automobile firms.

2.4 Summary of the studies and Knowledge Gap

Table 2.1 Summary of the studies and Knowledge Gap

AUTHOR	STUDY	FINDINGS	GAP
Demeter and Matyusz, (2011	The effect of lean practices on inventory turnover	High inventory turnover on lean companies using line production system. Batch production results in higher inventory turnover	Survey done on high-technological industries only hence findings cannot be applied on low-technological industries
Sumo,(2015)	Lean practices and supply chain performance among automobile assembling in Kenya	JIT significant to supply chain performance. Kaizen, Kanban & VSM are the most commonly used tools in automobile industry because of their simplicity in application. Flow and pull production are significant to supply chain	Management support is very important in the implementation of lean practices , failure by senior managers at the automobile industry show lack of commitment to the process hence implementation of lean practices is doomed to fail
Maina,(2013)	Lean management practices employed in manufacturing operations of food companies in Nairobi	Improved performance in inventory. Most firms haven't adopted the lean practices hence missing the benefits.	Production management changes with time either due to new product innovation, automation of the process lines or change in raw materials to produce the same

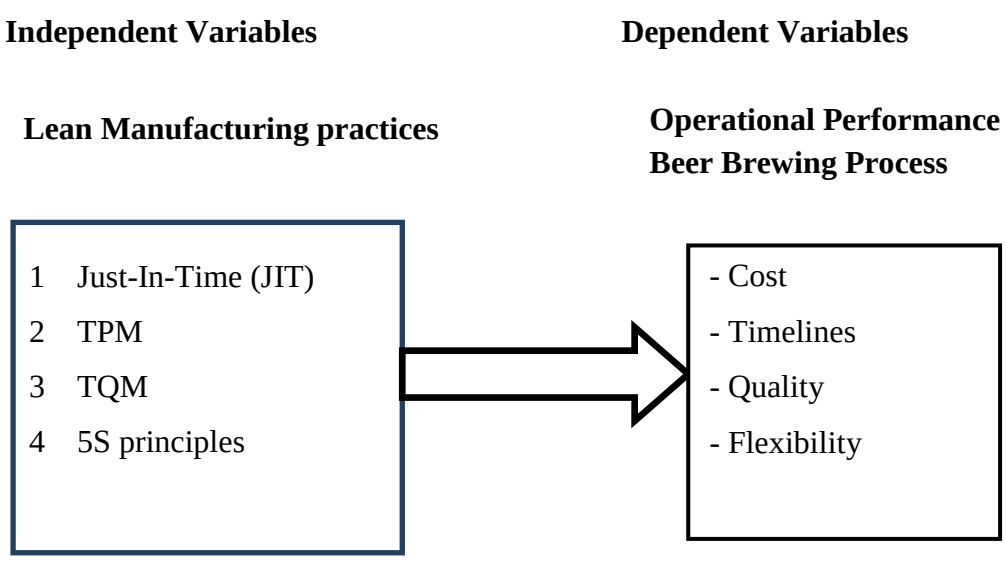
AUTHOR	STUDY	FINDINGS	GAP
			product, hence the findings may not be applicable across the time. Concentrated on food manufacturing firms in Nairobi only hence recommendation cannot be applied to other firms outside
Worley and Doleen, (2006)	The impact of management support and communication in implementation of lean practices	The support of management is very important in driving a lean manufacturing implementation. Lean implementation improves the communication system in the organization	Methods and means of communication didn't come out clearly. In shop floor Visual communication on boards is stronger source which was not mentioned. Data collection was done at early stages of lean implementation hence weak results
Julien and Tjahjono, (2009)	Implementation of Lean thinking at Safari Park Buckinghamshire UK	Process understanding at the park results into correct communication	JIT principle could have been used to regulate the feeds from

AUTHOR	STUDY	FINDINGS	GAP
		between the staff and the customers. Use of VSM increases the understanding of internal customers	the suppliers
Modi, Hong and Yang , (2010)	Impact of lean manufacturing and environmental management on business performance	Both practices are different and have differently effects on business performance outcome, being aware of the performance effects of environmental management is very important in light of the conflict between environment and economic objectives,	Firms have either discrete or continuous type of production processes, producing different products hence different amount of waste generated. This was not clearly mentioned hence the gap of application of the recommendation to either of the different processes.
Malonza , (2014)	Impact of lean practices and performance of Mumias Sugar Company Limited Kenya (MSC),	Improved machine reliability, poka yoke has helped reduce costly mistakes and accidents in the plant, automation has reduced production cost and VSM has reduced rework of materials and products	No mention of lean practices at MSC noted as below average for improvement. Sources of 34MW of electricity,24 Million litres of water,22Million litres of ethanol has not been mentioned yet MSC core business is sugar production

2.5 Conceptual Framework

According to Burns and Burns, (2008), a conceptual framework puts together abstract concepts as a first stage in creating a piece of research .For the objectives of the study to be achieved ,adopting conceptual framework will entail the following: lean manufacturing practices as independent variables and the beer brewing process as dependent variable. An independent variable explains the dependent variable either positively or negatively. A dependent variable is a construct that the researcher expects to understand, account for and /or predict during the study.

Figure 2.1: Conceptual Model



Source: Author (2016)

From figure 2.1 shows that for all the stages in the beer brewing processes, each stage relates to either one or multiple lean manufacturing practices and this is the measure of efficiency and effectiveness of the whole process.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter the discusses the design research, population, methods of data collection, techniques for data analysis and procedures.

3.2 Research Design

The design of research adopted was a descriptive case study. According to Kothari (2004), descriptive research is to explains the current situation as it exists at present. Kenya Breweries Limited was the unit of case study. According to Yin (2004), the aim of a case study is to provide insight into a particular situation, stressing on the interpretation and experiences of those involved. One case has been used since it represents an important, extreme and very unique case. Case studies can be used when it is not possible to adopt a sampling approach that seeks to generalize conclusions as if conditions were identical in other organizations, i.e., not possible to generalize from a case study but possible to generalize, or test, a theory ,Adam et al.,(2007).

Burns and Groove, (2003) defines descriptive research as research designed to paint a picture of a situation as it appears naturally. The design of research used in this study provides a picture of impact of lean manufacturing practices and operational performance of beer brewing process at Kenya Breweries Limited. The research study used was longitudinal. Longitudinal survey is an interrelationship research study that includes repeated observation of the same variables over long length of time.

3.3 Target Population

The population targeted was staff working at the brewing department, who include, brewing managers and the technical operators. The population was chosen because their core job is beer brewing only. The brewing managers oversee the whole beer brewing process while the technical operators, perform the actual process of operating machines to run the processes of beer brewing.

3.4 Data Collection

A qualitative and quantitative data collection approach was used for the study. Primary data was collected by carrying out interview with two technical operators and two brewing managers as brewing staff by use of an interview guide (see Appendix 1). The research objectives and the variables covered in the literature review, both form the basis of the interview schedule design. Mcgrath (2007) established that the use of in-depth interviews is effective in case studies as much depth of information in detail can be obtained as compared to other techniques. The interview guides contains both closed ended questions divided into two sections. Section A sought to get the general information, while section B sought to identify the extent to which lean manufacturing is adopted at KBL. Section C sought information on the impact of lean manufacturing during beer brewing process.

According to Lamb, Hair and MCDaniel (2010), Primary data main advantage is that it seeks to answer a specific research question.

Secondary data was collected from annual operation reports, journals and company literature at Kenya Breweries Limited. Information on secondary data is available hence saves time Kumar (2008).Trends and key performance indicators on beer

brewing process are shown by the use of secondary data , over a period of five years to supplement analysis.

3.5 Data Analysis

The data analysis process started with validation and verification of data to ascertain the correctness and accuracy of the information collected. The analysis was mainly qualitative and content analysis method has been used for the study analysis. Krippendroff (2012) defines content analysis as an indigenous communication research in social sciences. Cole (1988) defines content analysis as a procedure for written analysis, communication messages in Verbal or visual. Other researchers who have used this approach for their studies are Mwangi (2007), Kathuku (2005) and Njau (2000). The choice of this methodology was that it did not restrict respondents on answers and had the potential of generating more information.

CHAPTER FOUR

DATA ANALYSIS, FINDINGS AND DISCUSSIONS

4.1 Introduction

This analysis of data, findings and explanations drawn from the objectives of the study. The analysis was both quantitative and qualitative. The main objective of the study was to research on the impact of lean manufacturing practices and operational performance of beer brewing process at Kenya Breweries Limited. The research also tried to find out the extent of lean manufacturing practices and performance of all operations employed in beer brewing process at Kenya Breweries Limited.

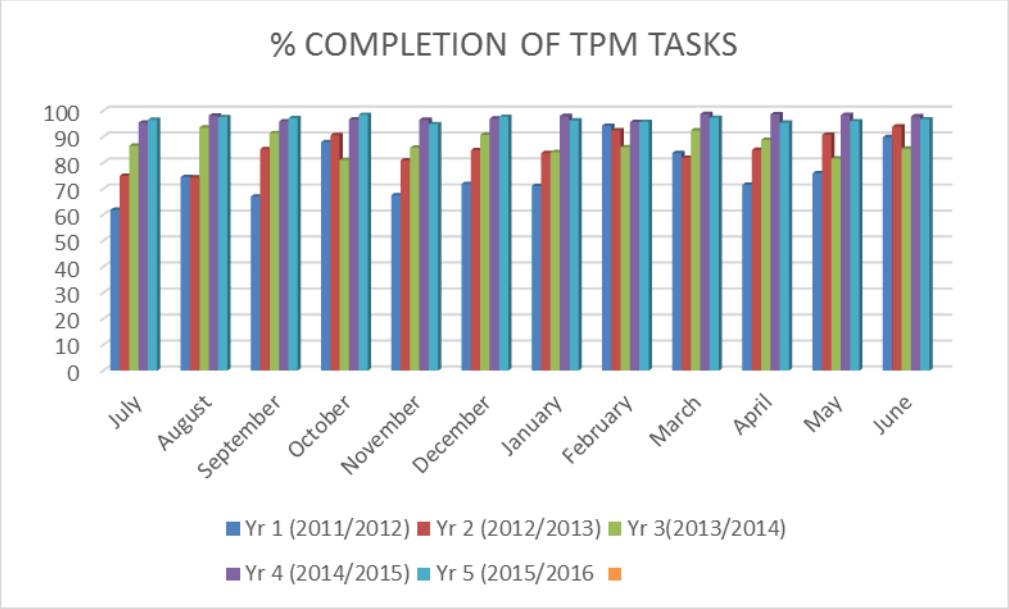
4.2 The Extent of Lean Manufacturing Practices and Operational Performance of Beer Brewing Process

The respondents acknowledged that lean manufacturing had been fully implemented for beer brewing process. Those interviewed highlighted that the extent of implementation was above average. They highlighted that all the systems and structures are in place and currently being followed. According to respondent JIT and 5S have been averagely adopted throughout the production process while TPM, Poka yoke, Continuous Improvement and TQM have been highly adopted and their adoption levels are well above average.

4.2.1 Total Productive Maintenance

TPM as a strategy of LM, strive to enhance machine efficiency and effectiveness through optimizing all types of maintenance activities. The respondents indicated that the O.E.E of beer processing machines are traced on 24hrs shift basis. Equipments are always in good working condition since they are maintained regularly.

Figure 4.2: Completion of TPM tasks



Appendix III and IV contains the Preventive maintenance (PM) tasks and their percentage completion, it is evident that Yr1 and Yr2 had a low percentage completion of PM task which indicates a low maintenance performance. Yr3, Yr4 and Yr5 show an increase in percentage completion of PM task depicting a high rate of maintenance performance. The increase in maintenance performance for the last three years has been attributed to: first the buying in by the machine technical operators and the use of computerized maintenance management system (CMMS). TPM is a maintenance philosophy that requires the total participation of the workforce.

The technical operators own the machines themselves, perform all the autonomous maintenance task (Cleaning, inspection, lubrication and tightening) on daily basis and raise tags on any failure, defect or any improvement action on the machine which are fed into the CMMS.

4.2.2 6S

According to Abdulmalek (2006), 5S pays attention on successive work place organization and uniform work procedures.5S has been applied averagely in brew house to maintain good housekeeping around the plant. According to the respondents they keep their workstation clean, which includes the processing machines. All materials and equipments are arranged and put where they belong. Beer production generates a lot of spent grains as waste, which are collected and sold as animals feed. Sustaining cleanliness and standardizing the process has been a big challenge.5S has been maintained in the plant to avoid contaminating the beer which affects the quality of beer .Poor quality of beer will increase rework adding extra cost of reworking which affects the delivery time to consumers. Good housekeeping is very important as it eliminates sources of contamination. The sixth S (food safety and Occupational Health and Safety Standard(OHSAS), which is safety of beer and operator is also in place and that explains why KBL has different ISO certifications like:IS0 22000:2005 for food safety. ISO 9001: 2008 for quality of products. OHSAS 18001: 2007 for health and safety standards for employees. The health and safety management system at KBL consists of number of company policies and approaches at each workplace to secure employee health at work and generate a safe and conducive working environment. The gap which was noticed is that no documentation of 5S since no data is always captured. Good housekeeping concept means differently to different people having different ideas to what constitute 5S and so is quantifying the level of good housekeeping.

The lack of proper quantification has resulted to the gap of no records for 5S as a LM practice. One point lessons are captured during the initial cleaning are pinned on the

wall which are assumed to be the benchmark for 5S and can be overruled by somebody else who thinks differently.

4.2.3 Total Quality Management

TQM is an unified organizational effort outlined to better quality at every level. In process quality index is a measure used to check the quality of beer at every stage during brewing process. During beer brewing the most common variable checked to get out the quality beer are: Temperature, Time, raw materials.

Quality control is done through regular quality checks as beer production is in progress, to ensure consistency in the quality of the end product. The respondents highlighted that visual controls colors are used, green color to indicate that quality is ok and red color to indicate that there is a quality problem. Statistical tools (graphs and paretto charts) are used to identify and control quality problem. The respondents have been empowered to stop the machine when a quality problem is detected during production and correct the problem. There are small quality teams that deliberate, discuss and suggest important issues for action.

4.2.4 Just - In - Time

JIT has been averagely adopted. The concept based on JIT, is that inventories are not valuable and should be regarded as waste. The respondent stated that raw materials are ordered to arrive just in time enough for a batch before beer brewing process begins. Throughout beer production the brewer and the technical operator, endeavor not to store inventory, especially work in process. Beer processes flow continuous at the stated time and quality. The processes are also well synchronized with time and brand. Supplier delivery is also managed to be just in time when raw materials are

needed. Some raw materials have to be in bulk in the warehouse, this is because of the lead time needed to import them from overseas hence the stock levels are high.

4.2.5 Poka Yoke

Poka yoke has been applied to for defects eliminations and correcting mistakes during beer production process. The respondents indicated this has been achieved through Automation of the production process. Distribution control system (DCS) has been employed to manage and automate the entire brewing plant. DCS stops the process when an alarm is generated indicating that the process has deviated from the standard and correction is needed for the process to resume .Supervisory control and data acquisition (SCADA) system has also been implemented in the process. SCADA system is a pictorial representation of the whole brewing plant .SCADA gathers information during production and the operator is able to operate, control and follow the whole process at one point .SCADA system do generate the location of fault which saves time to correct.

4.2.6 Continuous Improvement

Continuous improvement has been adopted above average level .There are daily meetings done to discuss the performance of the plant. These meetings are attended by the technical operators and managers where they raise new improvement ideas; actions are generated and followed up. The respondents stated that continuous improvement has increased their level of ownership as their ideas for process improvement are valued so much. They stated that issues raised by them and captured through CMMS are resolved faster hence making their life in operation easy.

4.3 Operational Performance

Operational performance data collected as shown in appendix IV, V, VII. This data was collected by use of data collection form in Appendix II. Analysis of data was descriptive content analysis. Data was obtained for planned preventive maintenance, overall equipment effectiveness, plant reliability and percent TPM task completion. Data that was not obtained was for IPQI, this is because it was not well documented for the whole process.

4.4 The Impact of lean Manufacturing at KBL

The respondents highlighted that there has been very big improvement during beer brewing by use of lean manufacturing practices. They highlighted that the main driver is improvement in brewing time efficiency, quality improvement and waste elimination during brewing process. Increased competition also featured as a driver to implementation of lean manufacturing. Keroche Breweries Limited, Heinken Breweries Limited and South African Breweries Limited are all in the same market hence fighting for the market segment. There are several benefits of lean manufacturing practices at KBL as explained by the respondents.

TQM is about improving quality of a product that comes from a quality process, through continuous improvement. A lot of improvement has taken place and brewing has employed some TQM practices in improving the quality: Benchmarking the business practices of other best brewing companies for the purpose of comparison like SAB miller and Heinken. Plan–do-study-act (PDSA) model which is an important tool in quality improvement work. PDSA creates new mastering by administering small tests of change with a lower risk, building self confidence in the effects of changes proposed. Employee engagement which forms quality teams who meet

regularly to solve quality problems. Use of quality tools like root cause problem solving (RCPS) and Pareto analysis techniques used to identify quality problems based on their degree of importance. Managing supplier quality to meet some preset standards of raw materials.

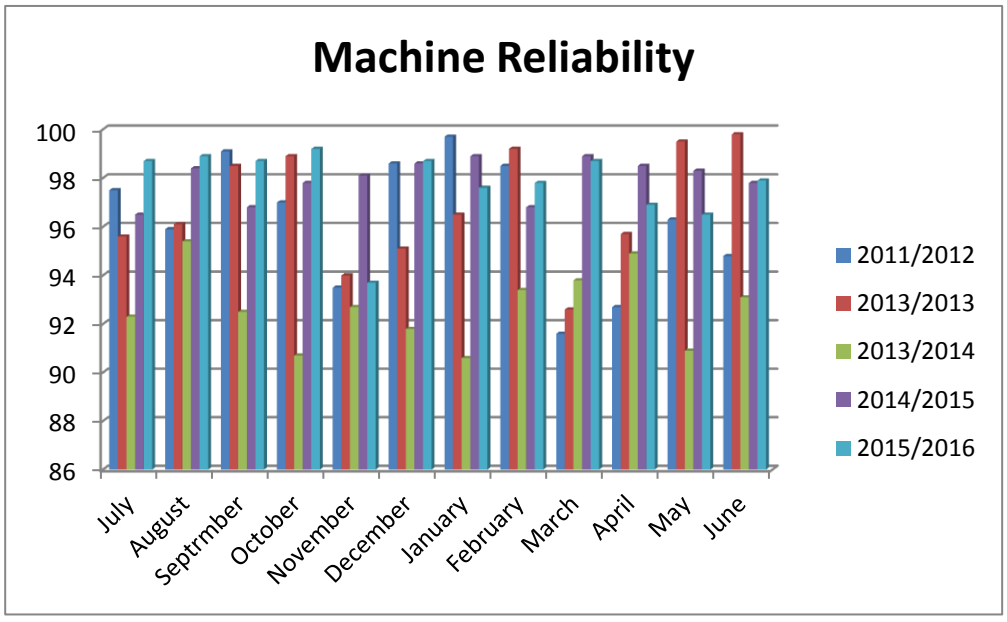
TQM has had a positive impact on the beer brewing process by improving the quality (IPQI) of beer being brewed. Improved quality means the beer is fit for use with no rework cost, customer delivery time is shortened eliminating long waiting times .Both volume and brand flexibility of beer production is experienced for it is a right first time batch production.

CMMS as a TPM tool has helped in maintenance planning and scheduling of the tasks raised. By using CMMS the planned maintenance tasks have been reduced on priority basis due to good planning which results into proper resource allocation. On maintenance planning the waste of skill has been reduced where the right numbers of technicians are allocated in relation to the most critical tasks raised and so is the cost of maintenance reduced. Scheduling by use of CMMS has kept check on the inventory of spares availability hence reordering levels. This has reduced the inventory cost and reduced the maintenance time by faster executing and closing of more tasks due to availability of spares. Maintenance is also planned such that it cascades through the process so that the maintenance work stoppages created by inventory shortages results in minimal disruption of flow.

Reliability is a measure of the likely hood that an equipment will perform its required function on demand under designed conditions. Appendix IX indicates that an average reliability of 96% throughout the five years under study was noted, this means the brewing equipment are fit for use hence available for better performance. Suenhiro

(1992) established that breakdowns of machines and minimum machine stoppages explains for an increase between 20-30% of loss in OEE. A machine with good reliability will increase the mean time between failures as it increases its throughput, OEE and product quality. There is also reduction in breakdowns (machine defects which result in product defects) hence a decrease in maintenance cost. The findings concur with Ljungberg (1998) who established that Volvo Gent announced that the company OEE before TPM implementation grew from 66% to 69% to 90% after TPM implementation, as a result of machine breakdowns and minor stoppages elimination. Beer is also brewed right first time hence elimination of rework. With high reliability there is flexibility of use for different brands of beer; this is because the required volume will be produced at the required time hence be ahead of beer production plan. Figure 4.3 below shows how the machine reliability has been for the past five years. An average of 96% reliability the plant has been able to produce the required volume of beer.

Figure 4.3: Machine Reliability



CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMEDATION

5.1 Introduction

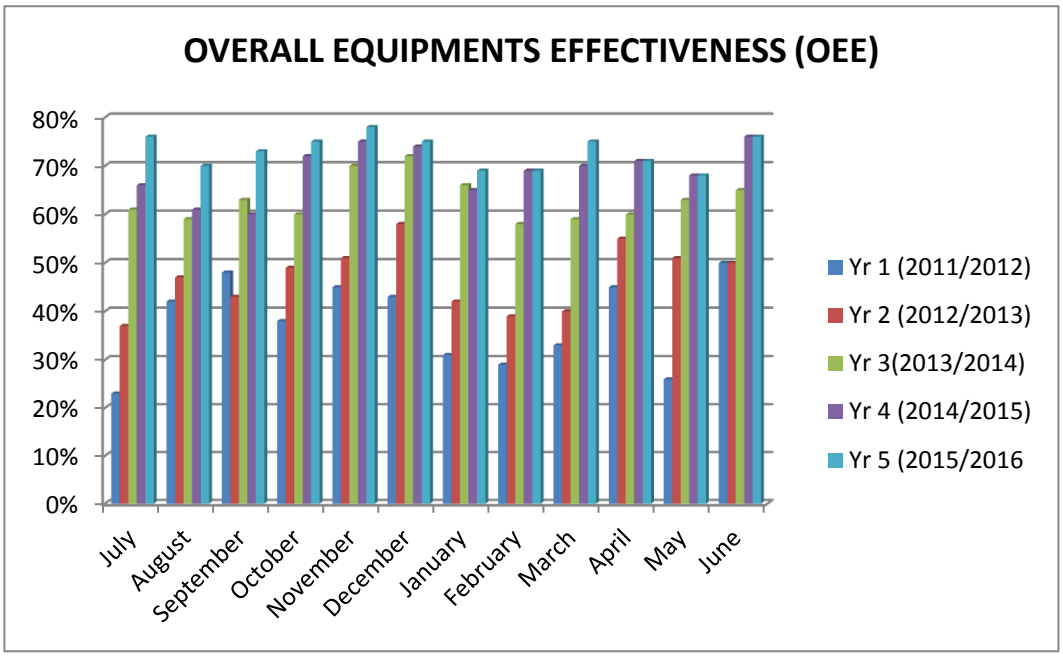
This chapter presents a summary discussion on impact of lean manufacturing practices and operational performance of beer brewing at KBL. A conclusion discussion on the general findings of the study is highlighted, followed by recommendations based on the findings of the study. Suggestions for further research and the study limitation are also highlighted.

5.2 Summary of Findings

The research finding reveal KBL has implemented the following lean manufacturing practices to the following levels. JIT and 5S have been averagely adopted throughout the production process while, Poka Yoke, continuous Improvement, TPM and TQM have been highly adopted and their adoption levels are well above average. KBL has all the systems and structures of lean manufacturing practices in place and have been implemented to the fullest hence KBL is reaping the full benefits of Lean manufacturing practices

Operation performance indicators have had a steady level. Percentage of maintenance task completion has been on average 85% completed. This has been attributed by use of one of TPM tool the CMMS in planning and scheduling of maintenance tasks. Successful TPM practices has reduced random machine breakdowns and increased the plant reliability to an average of 96%, hence availability of process equipments, increase in O.E.E and quality of beer, rework elimination.

Figure 5.1: Overall Equipments Effectiveness (OEE)



OEE as an operational performance indicator is seen to increase and stabilize from 2013 due to factors related to lean manufacturing.

The outcome on lean manufacturing practices on operation performance was found to be reliable. No beer reworks has been experienced and there has been an improvement in quality. Timelines have been meeting both for each beer brand during brewing process and the customer request. There has been flexibility for both different brands of beer and the required volume hence satisfying the market needs.

The impact of lean manufacturing at KBL include: Improved planning and scheduling maintenance task as a result of CMMS. Plant O.E.E and reliability has improved due to quick completion of PM tasks. Quality of beer equipments has improved as a result of TQM adoption. Poka yoke has improved by automating the plant, mean time before failure (MTBF) has increased and mean time to repair (MTTR) has decreased. Continuous improvement has improved the operator's machine and has made work

easier during beer production, eliminating a lot of operator's movement during production leaving the operator to monitor the brewing process only.

5.3 Conclusion

The findings of the research are consistent with research done by other scholars. The objectives of the study were: What is the impact of lean manufacturing practices and operational performance of beer brewing process at Kenya Breweries Limited? The question was answered with the objectives of study which were: To find out the extent of lean manufacturing practices and operational performance employed in beer brewing process at Kenya Breweries Limited and to gather and find out the impact of lean manufacturing practices and operational performance during brewing at Kenya Breweries Limited.

According to the respondents, they had high exposure to lean manufacturing practices hence a positive perception of the practices. Due to trainings on the lean manufacturing practices, the respondents acknowledged that their culture has changed positively and they think lean. Being technical operators they are at ease when the process machine reliability is high hence available for production and very minimal or no breakdowns during beer production. Employee safety comes first before everything at KBL. The policy says that you go back home safe, the way you came to work. The company has provided safety goggles, shoes, ear plugs, gloves, aprons among others and provided a safe working environment for the safety of the employees. TPM was ranked the best for having the most benefits in terms of taking care of the process equipment and waste (breakdown and stoppages) elimination by use of CMMS. TQM came second due to reduction of reworks by improving beer quality. Continuous improvements made the respondents own their process and were

free to make suggestion for any improvement which will improve both quality of beer and process, making their work environment safe during manufacturing. Housekeeping was also acknowledged by the respondents as it takes care of both food hygiene, their personal and work arrangement. JIT practice was also acknowledged by the respondents as it necessitates the delivery of beer brewing raw materials. The technical operators had no control over JIT practice. The brewing manager to had control together with the procurement. The table below shows the hierarchy of the lean manufacturing practices during brewing process according to the respondent's view.

Table 5.1: Respondents order of importance of LM practices

SAFETY – LEAVE IF IT IS NOT SAFE TO DO IT - GO HOME SAFE AS YOU CAME			
Rank	**Lean manufacturing Practice**	**Benefits during beer brewing**	**Gaps/ challenges**
1	TPM	Reduced machine breakdowns, increased machine Reliability, Increased machine OEE, use of CMMS, reduced machine set up time, Reduction in maintenance cost, Reduced MTTR , Increased MTBF	Spare parts taking long (lead time) to be availed especially from original manufacturers
2	TQM	Improved beer quality, Improved product volume, improved flexibility different beer brands production	Beer quality records not under the reach of technical operators easily
3	Continuous Improvement	Increase ownership levels, free environment for improvement ideas generating, improvement	Good improvement ideas not factored immediately due to quarterly budget

		of process and working environment	constraint
4	6S	Safety of employees (OHSAS), Beer safety, good housekeeping of workplace and tools.	No standard for good housekeeping. No records hence difficult to quantify since 5S means differently to different people.
5	JIT	Availability of beer brewing raw materials	High inventory because some raw materials are imported in bulk.

The study found out that lean manufacturing practices have had a positive impact on operational performance of beer brewing at KBL. There has been improvement on operational performance through improvement in quality, reduction in rework waste, reduction in production cost, reduction in timelines and increased flexibility in volume produced and different beer brands. KBL has fully implemented and adopted most of the lean manufacturing practices and therefore enjoys full benefit of lean manufacturing practices application.

5.4 Limitations of Study

Sample size is small this is because the process is the same hence with the same recipe for beer production. The study was constrained by the short time of data collection available. KBL has policy on data privacy hence not all data were available.

5.5 Recommendations

During beer boiling stage, hot steam vapour is emitted from the boiling vessels to the atmosphere as waste. The hot steam can be tapped and used to preheat water used for heating the cooking vessels. This can be an energy saving measure where less fuel will be used on the boilers to produce steam.

5.6 Future research

Cost of goods sold (COGS) is the total cost of raw material, cost of processing and overhead cost used to produce 500ml of beer. Future research to be done on COGS using lean manufacturing practices.

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APPENDICES

Appendix I: Letter of Introduction

Bernard Owuor
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To Whom It May Concern

RE: PERMISSION TO CARRY OUT A RESEARCH IN YOUR FIRM

I am a student at The University of Nairobi (UON), pursuing a Master of Business and Administration (MBA). I am undertaking a research project in partial fulfillment of the academic requirements. The topic of the research is 'IMPACT OF LEAN MANUFACTURING PRACTICES AND OPERATIONAL PERFORMANCE OF BEER BREWING PROCESS: A CASE STUDY OF KENYA BREWERIES LIMITED' KBL has been selected to form part of the study. I will be very grateful if you would spare sometime from your busy schedule, to respond to the questions listed on the attached interview guide and data collection form.

Your response will be treated with uttermost confidentiality. The findings of this research may be availed to you upon completion of the research if you so request. Your assistance and co-operation will be highly appreciated.

Yours faithfully,

Bernard Owuor

Appendix I1: Interview Questions

The interview guide is divided into 3 parts. Section A will be seeking general information, Section B will be seeking information on the extent to which lean manufacturing is employed on beer brewing process at Kenya Breweries Limited while Section C will be seeking information on the impact of lean manufacturing during beer brewing process.

Section A: General Information

Tick [√] correct answer

1. What is your job title?
   Technical Operator [ ], Brewing Manager [ ]
2. How long have you been in the brewing department?
   0-5 years [ ], 6-10 years [ ], 11-15 years [ ], 16-20 years [ ], Over 21 [ ]
3. How long have you worked in your current position?
   0-5 years [ ], 6-10 years [ ], 11-15 years [ ], 16-20 years [ ], Over 21 [ ]
4. I don't know what lean manufacturing is all about.
   Disagree [ ], Neutral [ ], Agree [ ]

SECTION B: EXTENT TO WHICH LEAN MANUFACTURING PRACTICES AND OPERATIONAL PERFORMANCE IS EMPLOYED IN BEER BREWING PROCESS AT KENYA BREWERIES LIMITED.

Interview questions

1. What lean manufacturing practices has Kenya breweries limited employed?
2. What is the level of implementation of each lean manufacturing practice?

SECTION C: THE IMPACT OF LEAN MANUFACTURING PRACTICES AND OPERATIONAL PERFORMANCE OF BEER BREWING PROCESS.

Interview questions

1. What benefits has process gained by implementing lean manufacturing?
2. What are the impacts of lean manufacturing practices implementation on operational performance of beer brewing?
3. What are the driving forces behind lean manufacturing implementation?
4. What is the general perception of employees towards lean manufacturing?

Appendix III: Data Collection Form

	Time line in years (Annual report figures)						
	2011	**2012**	**2013**	**2014**	**2015**		
OEE							
Reliability							
Quality							
% TPM task completion							

Appendix IV: % TPM Task Completion

Total preventive maintenance

Tasks 2011/2012

	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
No. of Schedule	3	3	2	2	3	3	2	3	3	2	3	3
No. Of Tasks	697	723	465	607	676	743	342	602	542	389	490	666
Tasks completed	432	541	312	534	456	534	245	567	454	278	372	598
% Completion	61.9	74.5	67	87.9	67.5	71.8	71	94.2	83.7	71.5	75.9	89.8
	TOTAL PREVENTIVE MAINTENANCE				**2012/2013**							
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
No. of Schedule	3	3	2	2	3	3	2	3	3	2	3	3
No. Of Tasks	702	658	548	425	587	658	435	741	658	410	603	724
Tasks completed	526	489	467	385	475	558	364	685	539	348	547	680
% Completion	74.92877	74.31611	85.21898	90.58824	80.91993	84.80243	83.67816	92.44265	81.91489	84.87805	90.7131	93.92265
	TOTAL PREVENTIVE MAINTENANCE TASKS				**2013/2014**							
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
No.of Schedule	3	3	2	2	3	3	2	3	3	2	3	3
No. Of Tasks	704	698	523	659	568	589	426	726	635	436	586	589
Tasks completed	609	653	478	534	487	534	358	624	587	387	478	503
% Completion	86.50568	93.55301	91.39579	81.03187	85.73944	90.66214	84.03756	85.95041	92.44094	88.76147	81.56997	85.39898

Appendix V: % TPM Task Completion

	TOTAL PREVENTIVE MAINTENANCE TASKS				**2014/2015**							
	July	August	September	October	November	December	January	February	March	April	May	June
No.of Schedule	3	3	2	2	3	3	2	3	3	2	3	3
No. Of Tasks	689	624	589	721	621	689	485	687	698	425	653	638
Tasks completed	657	612	565	697	599	668	475	657	689	419	642	624
% Completion	95.35559	98.07692	95.9253	96.67129	96.45733	96.9521	97.93814	95.63319	98.7106	98.58824	98.31547	97.80564
		TOTAL PREVENTIVE MAINTENANCE TASKS				**2015/2016**						
	July	August	September	October	November	December	January	February	March	April	May	June
No.of Schedule	3	3	2	2	3	3	2	3	3	2	3	3
No. Of Tasks	712	654	482	568	659	687	504	698	657	457	687	598
Tasks completed	687	638	468	559	625	671	485	668	639	436	659	578
% Completion	96.48876	97.55352	97.09544	98.41549	94.84067	97.67103	96.23016	95.70201	97.26027	95.40481	95.92431	96.65552

Appendix VI: % TPM Task Completion

	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Yr 1 (2011/2012)	61.9	74.5	67	87.9	67.5	71.8	71	94.2	83.7	71.5	75.9	89.8
Yr 2 (2012/2013)	74.92877	74.31611	85.21898	90.58824	80.91993	84.80243	83.67816	92.44265	81.91489	84.87805	90.7131	93.92265
Yr 3(2013/2014)	86.50568	93.55301	91.39579	81.03187	85.73944	90.66214	84.03756	85.95041	92.44094	88.76147	81.56997	85.39898
Yr 4 (2014/2015)	95.35559	98.07692	95.9253	96.67129	96.45733	96.9521	97.93814	95.63319	98.7106	98.58824	98.31547	97.80564
Yr 5 (2015/2016	96.48876	97.55352	97.09544	98.41549	94.84067	97.67103	96.23016	95.70201	97.26027	95.40481	95.92431	96.65552

Appendix VII: Overall Equipment Effectiveness

	Yr 1 (2011/2012)	**Overall Equipment Effectiveness (O.E.E)**										
	July	August	September	October	November	December	January	February	March	April	May	June
Plan	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
Actual	23%	42%	48%	38%	45%	43%	31%	29%	33%	45%	26%	50%
	Yr2 (2012/2013)	**Overall Equipment Effectiveness (O.E.E)**										
	July	August	September	October	November	December	January	February	March	April	May	June
Plan	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%
Actual	37%	47%	43%	49%	51%	58%	42%	39%	40%	55%	51%	50%
	Yr3 (2013/2014)	**Overall Equipment Effectiveness (O.E.E)**										
	July	August	September	October	November	December	January	February	March	April	May	June
Plan	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Actual	61%	59%	63%	60%	70%	72%	66%	58%	59%	60%	63%	65%
	Yr4 (2014/2015)	**Overall Equipment Effectiveness (O.E.E)**										
	July	August	September	October	November	December	January	February	March	April	May	June
Plan	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%
Actual	66%	61%	60%	72%	75%	74%	65%	69%	70%	71%	68%	76%
	Yr5 (2015/2016)	**Overall Equipment Effectiveness (O.E.E)**										
	July	August	September	October	November	December	January	February	March	April	May	June
Plan	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Actual	76%	70%	73%	75%	78%	75%	69%	69%	75%	71%	68%	76%

Appendix VIII: Overall Equipment Effectiveness

			Overall Equipment Effectiveness (OEE)									
	July	August	September	October	November	December	January	February	March	April	May	June
Yr 1 (2011/2012)	23%	42%	48%	38%	45%	43%	31%	29%	33%	45%	26%	50%
Yr 2 (2012/2013)	37%	47%	43%	49%	51%	58%	42%	39%	40%	55%	51%	50%
Yr 3(2013/2014)	61%	59%	63%	60%	70%	72%	66%	58%	59%	60%	63%	65%
Yr 4 (2014/2015)	66%	61%	60%	72%	75%	74%	65%	69%	70%	71%	68%	76%
Yr 5 (2015/2016	76%	70%	73%	75%	78%	75%	69%	69%	75%	71%	68%	76%

Appendix IX: Machine Reliability

	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Average
2011/2012	97.5	95.9	99.1	97	93.5	98.6	99.7	98.5	91.6	92.7	96.3	94.8	96.26667
2013/2013	95.6	96.1	98.5	98.9	94	95.1	96.5	99.2	92.6	95.7	99.5	99.8	96.79167
2013/2014	92.3	95.4	92.5	90.7	92.7	91.8	90.6	93.4	93.8	94.9	90.9	93.1	92.675
2014/2015	96.5	98.4	96.8	97.8	98.1	98.6	98.9	96.8	98.9	98.5	98.3	97.8	97.95
2015/2016	98.7	98.9	98.7	99.2	93.7	98.7	97.6	97.8	98.7	96.9	96.5	97.9	97.775
													96.29167