SUCCESS STORY ASSESSMENT OF LEAN SIX SIGMA IMPLEMENTATION AND DEVELOPMENT OF CONCEPTUAL FRAMEWORK FOR BEER GEORGE INDUSTRY: ETHIOPIA BREWERY COMPANY

A thesis submitted in Partial Fulfillment of the Requirement for the Award of Degree of Master of Science in Manufacturing Engineering

Under the Supervision & Guidance of

Kassu Jilcha (PhD)

by

Aychew Seboka Liche

ID Number: GSR/0076/09

MSc in Manufacturing Engineering

Program of Mechanical Design and Manufacturing Engineering

School of Mechanical Chemical and Materials Engineering

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Approved by Board of Examiners

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______________	__________	_________
Chairman, Department Graduate Committee	Signature	Date
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External Examiner	Signature	Date
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School dean	Signature	Date

DECLARATION

I declare that "**Success Story Assessment of Lean Six-Sigma Implementation and Development of Conceptual Framework for BGI Ethiopia Brewery Company: A Case of St. George Bottling Line Process**" is original work of my own. It has not been presented for a degree of any other university, and all the sources that I have used or quoted have been indicated and acknowledged by means of referencing. It is submitted in partial fulfillment of the requirements for the award degree of Master of Science in Manufacturing Engineering at Adama Science and Technology University, Ethiopia.

Aychew Seboka	________________	___________
Student Name	Signature	Date
Kassu Jilcha (PhD)	______________	__________
Advisor Name	Signature	Date

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Abstract

Lean six-sigma methodology is becoming very powerful improvement methodology in 21st century. More than 2100 studies were carried out regarding the implementation of the methodology on process industries since the beginning in 2000. Especially in developed countries like United Kingdom, United States of America and other countries. This methodology also implemented in some developing countries including African countries such as Nigeria, Uganda, Egypt, South Africa and others but it is in its binging stage. In addition, the study related to implementation of lean six-sigma methodology for food processing industries were very few including beverage industries because implementation on food process started lately and there is no specific framework developed. and also, there is no evidence that shows the implementation of this integrated manufacturing methodology in Ethiopian industries.

Hence, the purpose of this study is to assess the success story of lean six-sigma implementation in different industries around the globe through literature review and identifying the existing gaps and, develop conceptual framework for Ethiopia Beer George bottling line process. Literature review was categories in three (literature on lean, on six-sigma and lean six-sigma) based on title, abstract, keyword and conclusion and relevant papers were selected based on the year of publication, area of study and success story of implementation.

data has collected through interview, observation and measurement from both primary and secondary data sources and analyzed using Qualitative and Quantitative analysis methods including different lean and six-sigma tools like, Supply Input Process Output Control Diagram, Value Stream Mapping and Pareto Chart with the help of Sigma-XL v8 software.

As a result, the bottling line showed 8 different wastes and 74439 defected bottles per million which indicates the sigma level of the process is 2.944 sigma, 74% of the operation time is value added time and 66 minutes of the lead time is none value added time. In addition to that some critical success factors that will help for successful implementation such as communication, employee involvement and employee motivation and challenges that affects the production process such as bureaucracy in company process and shortage of green currency/dollar were identified during study in the company. proper Implementation of the framework will improve the quality of the product and will increase production capacity of the process by reducing defects and by eliminating wastes found on the bottling line.

Based on the finding, a conceptual lean six-sigma framework was developed for St. George beer bottling line process of Beer George Industry Ethiopia Brewery Company. During development of framework Define-Measure-Analyze-Improve-Control approach is used as base line and integrated with each other in all phases. implementation and validation of the framework will conduct in future.

Key Words: lean manufacturing, six-sigma methodology, lean six-sigma methodology, DMAIC tool, conceptual framework.

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List of Acronyms

AA: Addis Ababa

ANOVA: Analysis of Variance

BGI: Beer George Industry

CEO: Chief Executive Officer

DMAIC: Define-Measure-Analyze-Improve-Control

DOE: Design of Experiment

DPMO: Defect per Million Opportunity

DPU: Defect per Unit

EBI: Empty Bottle Inspection

ELV: End of Life Vehicles

FBI: Full Bottle Inspection

FMEA: Failure Mode and Effect Analysis

JIT: Just-In-Time

LSS: Lean Six-Sigma

MHN14: Mini Harflix 14

OC: Organizational Culture

OEE: Overall Equipment Efficiency

SIPOC: Supply-Input-Process-Output-Customer

SME: Small and Medium Enterprise

SPC: Static Process Control

SS: Six-Sigma

TPM: Total Preventive Maintenance

TPS: Toyota Production System

UK: United Kingdom

USA: United States of America

VSM: Value Stream Map

5S: Sort-Set in order-Shine-Standardize-Sustain

Chapter One

Introduction and Problem Approaches

1.1.1 Background

Lean management focuses its efforts on the ‘waste’ reduction and everything that do not generate value for the customer and, six-sigma dedicates to what the customers want and to produce the best quality products with a new methodology based on always on data to optimize the processes under statistical tools.

Six-sigma was invented at Motorola in the 1980s Barney, 2003. The invention was motivated by the high cost of poor quality discovered at Motorola. Like many companies at that time, it was as high as 15% to 20% of the sales revenue Barney (2003). The production processes had low capability. A large portion of the products failed to meet customer requirement. This led to scrap, rework, field service, or return or recall if the product has been already shipped to the customers. Obviously, if Motorola can improve its process so that very few defective products are produced, the cost of poor quality can be reduced significantly. This will directly contribute to Motorola’s (Pande, 2000). Motorola engineers hence proposed the concept of six-sigma, which means achieving a quality standard of less than 3.4 defects per million opportunities (DPMO). This is a very high standard since then industrial standard is about 35,000 DPMO before introduction of six-sigma (Bothe, 2002). In BGI Ethiopia Brewery industry there is a defected empty and full bottles that reduce the production capacity the process line those are found at four places where sensors are mounted (after washing, filling, labeling, packing processes) so to reduce those defects will use six-sigma methodology.

Lean manufacturing and six-sigma have different origins, the first one, in Toyota, a car company, and the second one, in Motorola, a producer of electronic and telecommunications products. Both are manufacturers that had different aims, but at the end, both strategies have become together the business excellence for its complementation.

Lean six-sigma is a combination of two powerful methods: lean and six-sigma, combining these two methods gives improvement team a comprehensive tool set to increase the process efficiency within the organization-resulting increased revenue, reduced costs and improved collaboration (web1, 2017).

In the history of Ethiopian brewery dates back 1922, 94 years ago. The year 1922 was just beginning to get ready to host things like modernism, the light of civilization, new development/progress, etc. Road had paved, cars were coming, construction of modern houses began, newspaper appeared, school opened, and the railways was streaming in one of the modern things that happened was the opening of brewery (Web2, 2017). Many got wonders of modernity. Some 20 years ago, the Ethiopian trade journal (1960), wrote “the St. George brewery is situated at Addis Ababa, and occupies an area” of 20000 Sq. meter of land. The brewery stands right on the same site it was 92 years ago. During the time of the last emperor it was known as marshal Smut Street. It was fairly big building and it started off as one of the pioneers in Ethiopian’s industrial development. The factory started with machineries that were operated by hand and foot and work was done by direct human labor. Transportation of raw material to the silo, fermentation of the malt, boiling the barley, filtering the beer, filling the bottles etc. were all done by manually (web2, 2017)

Over two decades passed, since Ethiopia has started privatization of its most government owned business sectors by transferring ownership to local investors and international companies. Especially the brewery industry is the most affected industry by privatization policy. Global brands like Heineken and Diaggo has joined the beer industry following BGI Ethiopia (web2, 2017).

The brewery industry is offering excellent employment opportunities, participating in different social responsibilities and contributing for the growth of economy. While consumption of beer has been on rise for the last decade, consumers have also become more refined in demanding more products. Meeting this growing and unsatisfying demand was not possible with the production capacity of factory in the country. In addition, beer exports over the last few years have been growing by a significant rate especially to neighbor countries like South Sudan (juba). The market gap, high demand for beer and other positive economic and political opportunities attracted international investors and companies for investment in Ethiopia (Web2, 2019). Because of international companies’ involvement in the industry, competition is becoming intense these days therefore investigating of the environment and necessary condition required for implementation of lean six-sigma methodology that will resolve those problems mentioned in the above statement (web2, 2019).

Currently the beer industry is the biggest sector of the alcoholic beverage industry in Ethiopia. In this competitive market, all the companies are trying to deliver a most quality and valuable products to the customer relative to their competitors. This implies lean six-sigma to be more important methodology in the current business environment. Lean six-sigma has a critical effect in companies’ competitiveness.

Therefore, this study assesses the success story different company around the world which has implemented lean six-sigma methodology and develop a conceptual framework for BGI Ethiopia plc. (St. George Brewery) after case study was conducted on the bottling line process. This implies introduction of lean and six-sigma manufacturing in the company and identification of wastes, variation and defect that influence the production of beer is the main focus of this study.

1.2 Statement of Problems

Many changes in the world of manufacturing has taken place. These are global competition, development of new manufacturing system, strategies and management. World competition is now a reality of manufacturing existence and this trend will continuous in the future. Traditional manufacturing process had a limited perspective of dealing with transformation of materials. According to (Idris Zerihun, 2004), the real key to success in manufacturing is to build the manufacturing system that can resolve the suffering of industries from problems of structure, lack of focus on manufacturing waste and product quality.

Lean six-sigma is a methodology to eliminate wastes and improve product quality in manufacturing process of the production companies in order to insure their competency. this methodology was adopted in different manufacturing organization around the globe including developed and developing countries. However, there is still a gap on implementation of this methodology.

According to Ibrahim et al., (2017) and Gunjan et al., (2016) even developed countries like USA and UK which have high rate of implementation of LSS methodology were succeeded partially. These countries have 70% and 75% frailer rate respectively because of lack of resource including time, availability of software and human resources. Which implies Large organization n struggle with problem of resource allocation to various competing project including developing process improvement project (Sowlati et al., 2005) and because of internal resistance and lack of leadership manufacturing organization also fails in success of LSS implementation (Timans et al., 2012). In addition to that there are many challenging factors which influence the success of LSS methodology implementation in manufacturing sector such as; it is time consuming, unmanaged expectation among the societies of the sector, lack of awareness about LSS benefits in business and lack of education and training (Saja et al., 2017).

Study conducted by Gunjan et al., (2016) mentioned that number of publications regarding LSS implementation in developing countries are very few. Adoption of LSS methodology in developing countries are struggling because of poor consideration of drivers including poor educational and supportive infrastructure. Implementing of LSS in food process industries is very difficult because of lack of properly organized and developed Framework that included food industries characteristic such as; demand uncertainty, high cleaning time, high setup time, traditional layout of the process, perishability, seasonality of the product, sequence dependence of the process and variation in raw material quality and supply (Luana et al., 2018). According to (Luana et al., 2018) there are only 6 published papers regarding LSS implementation in food processing industries since 2013. In Africa only two countries namely; Uganda and Nigeria implemented lean six-sigma on food processing industry which shows that the implementation in Africa is very low. Form (Luana et al., 2018) study only one Beverage industries was found that implemented LSS methodology.

In Ethiopia context, there is no evidence or published paper that showed the implementation of LSS methodology in any of industries including Beverage industries. BGI Ethiopia Brewery is one of the biggest and oldest beverage industries in Ethiopia. BGI Brewery Company has many team and production process including marketing team, production process team, quality control and product quality team and packaging team. In packaging team beer bottling line and other line for barreled beer are the process lines, the process of bottling line is processing an average of 13874688 empty bottles per month including defected bottle that reduce the production capacity and also because of this defects these causes delay in production time; unnecessary movement of operator; over processing of defected bottle; wasting of produced beer and other resource materials and re work which resulted on dissatisfaction of both the company and customers of the company.

The combination of those problems affects BGI Company by reducing product capacity that means the company cannot deliver required amount of product with in required time also brand in not competent in the world market, but the exact impact has not been quantified in to solid data thus far. For this reason, implementation of Lean Six-sigma on Bottling Line Process is required. Therefore, assessing the success story of lean six-sigma methodology and developing conceptual lean six-sigma framework for BGI brewery bottling line is the focus in this thesis.

To this end the research will address the following questions:

- ➢ What are the factors affecting and challenging the company in bringing wastes and defects to the bottling line process?
- ➢ What is the Current Value Stream Map of bottling line process?
- ➢ What is the strategy to overcome those wastes, defects and challenges found on the bottling line?

1.3 Objective of the Study

1.3.1 General Objective

The general objective of this study is to assess the success story of implemented lean six-sigma methodology and develop conceptual framework for BGI Brewery Company bottling line process.

1.3.2 Specific Objectives

In this thesis there are three specific objectives including:

- ✓ To identify factors of all wastes and defects that affect bottling line process.
- ✓ To Draw Current value stream map (VMS) to understand the flow of the process and know the place were wastes and defects will occur exactly.

- ✓ To Develop a conceptual framework that will modifies the current situation of the company

1.4 Scope and limitation

the study is restricted only to development of lean six-sigma conceptual Framework for BGI Brewery Company bottling line process based on the existing related internet materials found and data found through case study on the bottling line process.

It is clear that such a research topic demand long period of time to comprehend every detail of the subject matter. Moreover, the availability of related resource materials on the topic is very scarce. because of these two reasons this thesis is limited to implement and validate the Framework on the bottling line and also forced to used resource materials related to different topics in manufacturing organization other than topic related materials.

1.5 Significant of Study

Conducting this study in BGI Ethiopian Brewery Company will help the company to clearly understand the process, types and sources of wastes and defects found on the line and motivate them to improve the process by implementing the methodology. In addition, this study will give new insight regarding LSS Framework implementation on global and local brewery and other beverage industries and also it will also be an educational and research resource material for other organization and researchers.

1.6 Research Organization

This thesis has seven chapters. Introduction, background, statement of the problem, objectives and scope and limitation, and significant of the study were discussed under chapter one. Literature on Lean manufacturing, Six-sigma methodology and Lean Six-sigma those related to the research were reviewed under chapter two.

In the third chapter, the research design was formulated and methodology used for case study including type of data sources, data collection methods, data analysis methods, ethical consideration and dissemination and utilization of results were discussed.

In chapter four, information regarding the company and the bottling line process were gathered and explained including Qualitative and Quantitative data from interview, observation and measurement.

In the fifth chapter, data were analyzed using analysis methods with lean and six-sigma tools like SIPOC, Pareto chart, current state map of the process, current level of sigma and with Sigma-XL V8 software. Results found during analysis were also discussed under this chapter. In chapter six, a conceptual framework was developed and implementation procedure was explained. in the last chapter, conclusion, recommendation and future work of the paper were stated.

Chapter Two

Literature Review

2.1. Introduction

This literature review focuses on researches related to lean, six-sigma and lean six-sigma done since 1990s.The purpose of this research is to identify previous and recent relevant studied research materials and to find related gaps which helps researcher to investigate the implementation of lean six-sigma manufacturing philosophy and recommend to the bottling line process of BGI brewery if it implementable to eliminates wastes found during investigation and improves quality of product by minimizing defects on the product or to find out if it not implementable. This study reviewed more than 125 articles, books and other data source related to lean, six-sigma and lean six-sigma methodologies. Titles, key words, abstracts and conclusion were reviewed. And finally, 36 related articles and books used for this thesis.

Definition of Terms

Craft Production: This is simple production process with a highly skilled person and uses flexible tool to produce what customer ask for. This kind of production produce one item at a time but it is very costly (Idris Zerihun, 2004). Batch production and job production is two common types of craft production.

Batch Production: is a production process that produce a batch of items by taking through a series of steps together.

Job Production: is the one-by one production of a unit items that may be customized for the customer.

Mass Production: This kind of production produces items in high volume using semiskilled and unskilled person which operates a single machine that has very high cost. This mass production also results in extra buffer, extra space and extra worker to make sure production is smooth. In this production the procedure keeps standard design for long time which results customer gets lower cost but at the expense of Variety and the employee also gets bored and depressed (Idris Zerihun, 2004).

Lean Production: In contrast to the above two production types lean production is very good kind of production because it uses multi skilled employee in all label of the company, it is highly flexible, it also uses automated machine to produces in mass (Idris Zerihun, 2004).

According to Womack (1990) Lean term inside the industry was created by a research group which wanted to reflect both the idea of the Toyota production System and to compare with the mass production of the American system.

Shah R. and Ward P.T. (2007) described lean production or lean manufacturing is directly descended from the Toyota Production System (TPS). Lean production or TPS is absolute elimination of wastes Womack (1996); he also said that lean production uses half the human effort in the factory, manufacturing space, the investment in tools, the engineering hours to develop a new product in half time.

From the above the difference between lean production and mass production is their goal; in mass production the goal is producing a narrow range of standard with acceptable number of defect and maximum acceptable inventory. While; in the case of lean production the goal is to produce perfect, continuously declining cost and endless product Variety with zero defects and zero inventories.

Linderman et al., (2003) said that Six-sigma was indicated by Motorola Inc. in the 1980s and has been defined as “an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defects rates”.

Lean six-sigma is a combination of two very powerful manufacturing methodologies which are lean manufacturing and six-sigma methodology those maintained above.

George M.L. (2002) defined Lean Six-sigma concept as “it is a methodology that maximizes shareholders value by achieving the fastest rate of improvement in customer satisfaction, cost, quality, process speed and invested capital.” also the combination is necessary because Lean cannot have a statistical control process, and on the other hand, Six-sigma cannot get totally better results in the process speed or in the reduction of the invested capital (George, 2002).

2.2 Types of Waste and Tools in Lean Manufacturing

2.2.1 Wastes in Lean Manufacturing

Alarcon L. (1997) defined “waste” as any loss produced by activities which cost directly or indirectly to the company but do not add value to the final output from the point of view of the customer. Waste is measured in terms of costs, there are other kinds of waste that are not related to the product and they are also wastes because they reduce the efficiency of the processes, equipment or employees, but these are more difficult to measure.

According to Ohno T. (1999) there are seven original wastes in manufacturing process which mentioned below: -

Overproduction: is when the production is higher than the required or it is produced before the right moment.

Waiting time: is a lack of synchronization, delayed operations or changeovers times.

Transportation: is referred to internal movements of the materials, so it should try to create the best for routes of the materials and the layout for the products.

Over processing: appears when there are mistakes in the process and could be avoided.

Inventory: is excessive or unnecessary inventory and this creates deterioration and stock.

Movement or unnecessary motion: is when the workers made usefulness movements due to a bad workshop situation.

Making defective product appears when the final or intermediate product does not achieve the requirements.

More recently, some other wastes have happened including **underutilized people** and also waste of energy and waste of resource materials.

To Summarize, lean production is highly flexible and uses multi skilled employees compare to craft and mass productions. According to (Alarcon L., 1997 and Linderman et al., 2013) there are

8 manufacturing wastes including underutilized people and different kinds of product defects in different organization which results in reduction of product and process quality that cost the company directly and indirectly. Lean six-sigma is an integrated methodology to eliminate those wastes and improve product and process quality.

2.2.2 Tools in Lean Manufacturing

There are almost 100 tools for lean practices and with time, there are going to be more and extensive collections of lean practices as suggested by various researchers the selection of lean practices should be made wisely to guarantee a successful implementation.

According to Bamford et al., (2015) the selection of lean practices should be made based on the nature of the process or works. It is important that a manufacturer has enough knowledge on lean practices, so that they understand the workings of lean implementation.

Value Stream Mapping (VSM)

Haines and Rich (1997), Jones and Womack (2000) defined VSM as a process of visually mapping the flow of materials and information that includes all value added and non-value-added activities in the process that are required to bring a product or a group of products. VSM technique is the first stage of analysis used in most lean manufacturing implementation which provides a systematic approach for waste identification, lean tool selection and implementation (Don et al., 2002).

VSM is used to map the current operating state for production line, this map is used to show where is the sources of waste, the flow of information and materials and helps to select appropriate lean tools for eliminate wastes and then used to map what should be the future process of the organization. To draw current VSM there is analysis which helps to know the numerical data those are necessary for the mapping. Those data and their analytical formulas are the following: -

batch number, cycle time (time since an item starts its manufacturing process until it finishes), speed (bottles/hours), total time and down time (unplanned stoppage time of the process).

Takt time =available working time/number of bottles

Total lead time = value added time +non-value-added time

Up time (%) or over all equipment efficiency $= \frac{\text{total time} - \text{down time}}{\text{total time}} * 100$

Standardization

Manfred F.R., (1999) the word standards and standardization are sometimes mentioned in Lean manufacturing and continual improvement methodologies. The first word standard is defined as "A standard is an approved specification of a limited set of method to actual or potential matching problems, prepared for the benefits of the parties involved, balancing their needs, and intended and expected to be used continuously, during a certain period, by a substantial number of the parties for whom they are meant".

This concept is really important in the Toyota Production System besides it is one of the most powerful lean tools. Of course, it is also connected with the techniques already explained because most of the Lean techniques want to be able to solve the problem fast to reduce wastes like time and to behave in the same way. Standardization makes the solutions to a problem and with the idea of apply them continuously, as a result, the worker knows the steps to act and can perform better, improving the safety, quality, variability, because it is not related with who executes the process (Manfred F.R., 1999).

The standardization work is the base of the Kaizen methodology that means continual improvement. It is understood by Linker et al., (2006) that a process must be a work which is repeatable to be carried out for being able to standardize, otherwise is not recommended to standardize. Likewise, the process should work under certain quality because it cannot be stopping continuously if the company wants to achieve some profits.

5S

5S is one the most widely adopted techniques of lean manufacturing. Along with standard work and TPM, 5s is considered as a foundation of lean concept, as it established the operational stability required for making and sustaining continuous improvements.

It is a method of creating a self-sustained culture which preserves a neat, clean and efficient workplace and also it is a method for removing all excess materials and tools from the workplace and organizing the required items such that they are easy to find, use and maintain.

2.3 Lean Thinking

Up-to-date it is known that Lean was originating from Toyota Motor Company and based on its philosophy Toyota Production System. Lean it can be defined with the reduction of the eight wastes including underutilized people explained before. However, Lean is much more because it is also built under a theory that the organizations are formed by processes. There are five Lean principles Womack (1996) which are a sequential way for organizations to add value, eliminate waste and improve thanks to a repeating continuous improvement 'kaizen' process. Those principles are explained as follow: -

Define accurately the value from the customer view and specify the value desired of the customer associated to the product, capabilities, price and time. It is important because it might be adding value to the company but not to the end customer, so, it could be resulting the wrong product or service and generating waste.

Identify the value stream for each product or service and eliminate the waste. There are three critical activities, product definition (from design to launching), information management (from order taking to delivery), and physical transformation (from raw materials to finished goods). Identifying the value stream, it is an indeed way to realize about unnecessary steps in each product and department.

Make the remaining value creating steps flow. Standardizing processes based on kaizen and also in the thinking that there is no waiting, downtime or scrap within or between the steps of production.

Design and provide what the customer need at the time the customer wants. It means a 'pull' system reducing inventory 'muda', so, a JIT application, because the company does not produce any product which is not desired. The idea is to create, on the same way, a flexible production process.

Pursue Perfection. There is no end in the search of perfection in the processes but constant re-evaluation and upgrading and optimization is the way.

To sum up, many lean tools were used in different Organization but not all of them in a single Organization. the selection of lean practices should be made based on the nature of the process or works Bamford et al., (2015). In addition, there are five Lean principles which are a sequential way for organizations to add value, eliminate waste and improve the process Womack (1996).

2.4 Literature's on Company those Implemented Lean

According to Abdullah A. and Patrick M (2018) Organizational Culture (OC) is one of the most important factors to focus on facilitating the implementation of Lean. Studies have shown that many researchers are in agreement that an Organizational culture which does not support Lean is a large reason for the failure of successful Lean Implementation. According to Davis (1984) culture is defined as, the pattern of shared beliefs and values that give members of an institution meaning, and provide with the rules for behavior in their organization".

The aim of paper is to explore and evaluate Lean Implementation into small and medium enterprise manufacturing organizations in Saudi Arabia by leveraging aspects of Organizational Culture. The objective of the paper was to investigate, explore an organizational culture that influences lean implementation with in Saudi Arabian SMEs and develop challenges of an Organizational culture that facilitates Lean implementation, questionnaire to gauge the current idea position Lean implementation and culture ideal position that manufacturing SMEs should aspire to the most effective Lean Implementation.

The research was conducted based on qualitative and grounded theory inside action research with and an inductive approach. Interviews and observation were also conducted on selected companies of Saudi Arabia. NVIOV software was used for data analysis in qualitative research (Abdullah A. and Patrick M, 2018).

Data was collected in two stages, where in the first stage six selected companies which are steel, electric, oil, paper, packaging and construction industries, which are in Saudi Arabia were visited and a total of 29 semi-structured interviews were conducted with employees of all levels from Chief Executive Officers (CEO's) to factory workers. In the second stage of data collection the researchers conducted two focus groups after semi-structured interviews. The sampling for both focus groups has been selected based on the candidates' experience. Both focus groups had the same participants. Focus group one was engaged on review of semi-structured interview results and the second group was engaged on aggregate the cultural aspects developed into higher level challenges (Abdullah A. and Patrick M, 2018).

As a result, 37 aspects were identified and compared with the literature reviewed. All these aspects have been reviewed and discussed by participants through Focus Group One. Thus, produced aspects, each aspect has a definition. Moreover, categories were identified during Focus Group Two by grouping all the aspects. Therefore, change management and behavior patterns need to be considered (Abdullah A. and Patrick M, 2018).

In conclusion, the paper aims to identify aspects of Lean Implementation in SMEs in the Saudi Arabia. 37 aspects have been identified from semi-structured interviews. All these aspects have been aggregated through focus groups. The paper fulfills an identified need to study how the Organizational Culture Affects Lean Implementation. It contributes to the current state of Lean Implementation in manufacturing companies by uncovering the correlation between enablers and inhibitors of Organizational Culture in Saudi Arabia (Abdullah A. and Patrick M, 2018).

Piotr W. (2014) presented the attributes of Lean organizational culture as positive organizational culture in his conceptual research. The objective of this study was to present Lean organizational culture's attributes related with the application of the perception of Lean Management in the enterprise on a high level of competence. Questionnaire that has 7 rating level was prepared to analyze and diagnose the culture. As a result, bigger barrier in this process was lower and middle management. Lean conception disturbs their previous "calm" life in the organization and breaks traditional solidified until now rules of their acting. Some people think that it also decreases their power and reduce their authority; But, only in accordance to traditional way of understanding these issues. One more thoughtful threat is added; terminating of a part of management positions. That is why changing these aspects among the company's management is the bigger difficulty than changing awareness, mentality and attitude of line employees in a process of Lean Management's implementation.

The key for the success in this process is fundamentally a successful change of attitudes, mentality and styles of top management's performance. In the early period, the enforcement of some actions from the area of new cultural standard is essential, but after some time, if the employees realize the wisdom that the applied solutions simplify their work and result in higher wage, they are willing to join the activities of Lean character and at the same time they correct their attitudes and organizational behaviors (Piotr M., 2014).

M. Belle (2008) said that “the most important from the point of view of the level of succeeding this process is understanding the difference in culture, mostly among top management whose tasks is to execute a leading role in this process”.

Haffer R. and Glińska-Neweś A. (2013) stated in Lean Management changes of organizational culture are made first of all by the active involving the employees in the actions which are of organization’s change character (participation in Lean projects, 5S and kaizen on own job site, active involvement in TPM and SMED activities and suggestions systems) during which the employees on the basis of own experience become influenced that Lean does not consist in harder, longer or more fatiguing working but in working in a wiser way. But in order to involve employees all the aspects mentioned above must be preceded by appropriate training.

Islam et al., (2018) said that in car dismantling companies, increasing efficiency might thus result in more throughput and reduced lead time. Increased output which would help the company to meet the demand of processing more End of Life Vehicles (ELV), and reduction of lead time would result in faster supply of materials to downstream companies thus shortening the lead time of whole recycling chain.

The objective of this Literature is to investigate how Lean manufacturing techniques can contribute to improve the production system of ELV dismantlers. they used value stream mapping and task analysis as methodology in case study which identified different types of wastes involved with disassembly operation in dismantling station and analyzed flow process. And also, kaizen was used to eliminate those wastes. Data were collected observation of dismantling station and interview of the CEO (Islam et al., 2018).

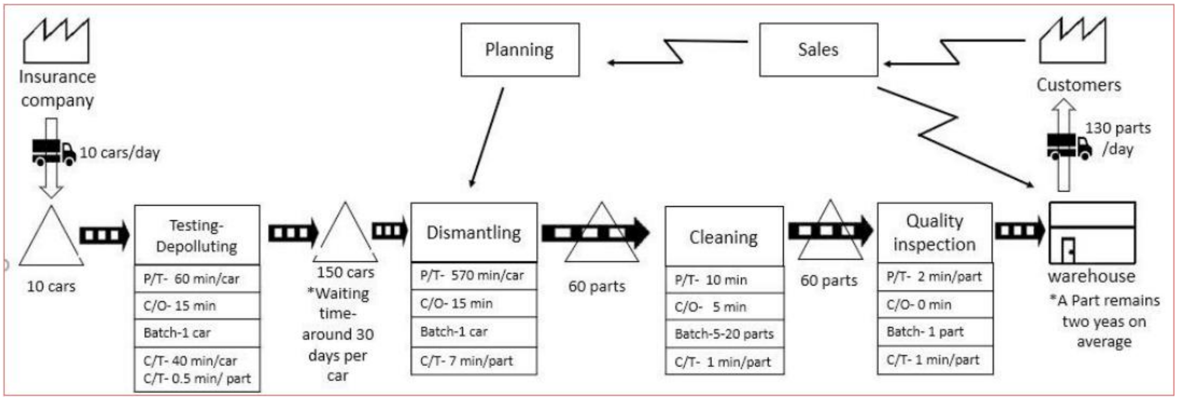


Figure 2.1: Value Stream Mapping of Dismantling Station (Islam Et Al., 2018)

The Figure2.1 shows the flow process of dismantling station that consist of four major operations for disassembly Testing & Depolluting of ELV, Dismantling the parts, Cleaning the extracted parts, and finally Quality Inspections. At the beginning of the process 10 cars were introduced to the line of disassembly and in each operation, parts were removed at the end of the line totally 50 to 100 parts were stored in to the warehouse for three months to two-year period of time. Buffer between each operation is 60 parts which indicates that there was inventories waste. Overproduction was also another waste because of disposal of 10% of parts from warehouse to free the space (Islam et al., 2018).

Dismantling operation was included manual extraction of reusable parts for this reason processing time of the dismantling operation was very high and it required further analysis. For a single car 70% of the whole processing time corresponded to value adding tasks, whereas required non-value adding tasks and pure waste were 21% and 9% respectively. After they identified all wastes, they conducted root cause analysis and they found that, it was small possibilities to reduce the inventory and overproduction because of the characteristics of the business (Islam et al., 2018).

According to Islam et al., (2018) unnecessary movement in the dismantling station which occurred mostly because of walking, rearranging the workplace seemed to have a potential to cut down this waste by half. Because of the time constraint, it was not possible to implement the design of a new workplace and find out the actual result. It was hypothesized that through engaging multiple operators to disassemble one car at one workstation, the output could be increased. This was also studied in an experiment where the result showed the same output per man hour as if they would have worked individually with different cars.

The task analysis showed- 70% of value-added tasks, 20% of required non-value adding tasks and 10% of pure wastes. The result they found shows variation from the result of previous research done by Kazmierczak which were value adding tasks- 30%, and 70% of non-value adding tasks. There might be several possible reasons for the variation. First of all, the definition of considered value adding and non-value adding tasks might be different as it is based on judgments of the observer. Secondly, the disassembly time and the way to disassemble of a certain part vary a lot based on car model, damage type and operators' skill. Finally, the number of samples might be another crucial factor of this variation. (Islam et al., 2018)

After the above finding and discussion, they suggested kaizen as process improvement tool and it may result in reduction of movement of operators, which could lead to a decrease of cycle time in dismantling stations by 5%. It would help to attain better flow, which is in line with studies identifying optimal facility and workstation layouts (Islam et al., 2018).

They conclude that implementing several lean tools such as Kaizen, 5S, Kaizen Event, standardized work to reduce wastes involved with the operational processes which would contribute to increase the efficiency and output. Generally, this could be beneficiary from lean implementation (Islam et al., 2018).

Rafiq et al., (2018) developed and implemented the powerful lean tool of value stream mapping to present a pilot learning factory with a case-study in Albert learning factory through project-based assembly procedures by means of in-house designed LEGO 3D printer for assembly line that has 7 work stations; The goal the study at All Factory was to deliver changeable products or reconfiguration systems to the students, which can be re-assembled for interchangeable operation. Every workstation has a standard work instruction sheet, a material storing container and a status board for recording data on performance.

The students were allocated per station to collect information regarding the line including cycle time. The mission given was to stabilize the cycle time at each station to nearly 15 minutes and make the process flow smooth. As a result, the lead-time of the total process was 210 minutes previously VSM. Afterward the VSM, lead-time was reduced to 137 minutes which indicates 34.27% of lead time is reduced (Rafiq et al., 2018).

To summarize, many authors conducted researches regarding lean manufacturing implementation in different organization. Abdullah A. and Patrick M (2018), Piotr W. (2014), M. Belle (2008) and Haffer R. and Glińska-Neweś A. (2013) discussed about the influence of organization culture change on the implementation of lean manufacturing. Abdullah A. and Patrick M (2018) focused on the influence of cultural change on implementation of lean manufacturing in SMEs organization in Saudi Arabia, as a result, change management and behavior patterns need to be considered. Piotr W. (2014) and M. Belle (2008) discussed and concluded that fear of change among lower and middle managements was the biggest barriers in the organizational operation and suggested that successful change of attitudes, mentality and style of top management performance were the key for successful implementation of lean manufacturing. Haffer R. and Glińska-Neweś A. (2013) said that employee's active involvement in organization activities is an essential factor for cultural change.

Islam et al., (2018) and Rafiq et al., (2018) developed and implemented lean manufacturing in order to reduce cycle time and lead time of automotive and in-house designed LEGO 3D printer assembly line process they used different lean tools including VMS, 5S, Standardization work and kaizen. As a result, they found 5% reduction of cycle time (Islam et al., (2018)) and 34.27% reduction of process lead time (Rafiq et al., (2018)).

Generally, fear among low and middle labeled managements is the biggest barrier in organization operation. In order to succeeded on implementation of lean manufacturing; successful change of attitude, mentality and style of managements including active involvement of employees and proper selection of lean tools play a main role among Organizations.

2.5 Six-Sigma

In recent years one of the outstanding issues with regard to quality is six-sigma (Tekin M, 2013). Six -sigma can also be defined as the process quality management that leads us to excellent quality level through continual improvement of processes (Tekin M, 2013). Six- sigma is also a quality management model that ensures the elimination of mistakes by focusing on the mistakes in processes (Tekin M, 2013). According to six-sigma approach while the sigma level increases the quality level also increases accordingly. The base of the six-sigma is related to statistics. The sigma (δ) is the symbol of standard deviation. Standard deviation is a measurement unit for statistical dispersion and spreading.

In this regard Six-sigma is a customer focused improvement strategy. This is used as a methodology in order to reduce the mistakes level to 3.4 mistakes per million in product design, production, delivery, and management processes. Six-sigma focuses to obtain the same result every time and utilizes the well-defined problem-solving approach via statistical tools.

Six-sigma focuses to the following three topics those are Increasing Customer Satisfaction, reduce cycle times, reduce failures. The next table shows six sigma performance levels that is equivalent of making only 3.4 mistakes per million possibility or interactions and DPMO of Sigma Levels.

Table 2.1: Counts of failure per million (DPMO) and their meanings in various sigma levels (Tekin M, 2013)

Capability of process	Ppm (parts per million)	Meaning
1,5 δ	500000	%50 Products are thrown away to garbage
2δ	308537	Approximately % 31 products are thrown away to garbage
3δ	66807	flying per million are faulty
4δ	6210	6210 per million surgical operation are done wrongly
5δ	233	Numbers of news per million are given wrongly
6δ	3.4	3.4 hours cutting off electrics in a million hours

2.5.2 Defects

According to Frank B. Watts (2009) Defect "is product that is not fit the required specification the process needed or it is a product that the customers are not willing to pay for it". Defects directly add to the costs of goods produced, this may comprise delay on delivery time, mistakes in paperwork, delay on production according to incorrect specifications, use of too much raw materials or generation of unnecessary scrap Manjur Ayon, (2013). When defect occurs, rework may be required; otherwise the product will be scrapped. Generation of defects will not only waste material and work resources, but it will also create material lacks, delay meeting schedules, create idle time at subsequent workstations and extend the manufacturing lead time (Firoz Kabir, 2014).

2.5.3 Six-Sigma Approaches

Six Sigma methodologies have two approaches (Adrian et al, 2016):

The first is “DMAIC stands for (Define, Measure, Analyze, Improve, Control).), which is applicable to an existing product or process to be improved.” And the second approach is “DMADV stands for (Define, Measure, Analyze, Design, and Verify) which is applicable to new products or processes, to be designed and / or implemented in a manner that will provide a Six-Sigma performance”.

DMAIC Tools

As maintained in section 2.5.3 DMAIC was used to improve already existed products or process and different statistical tools of six-sigma are integrated and used in this approach. the following diagram shows detail about DMAIC cycle.

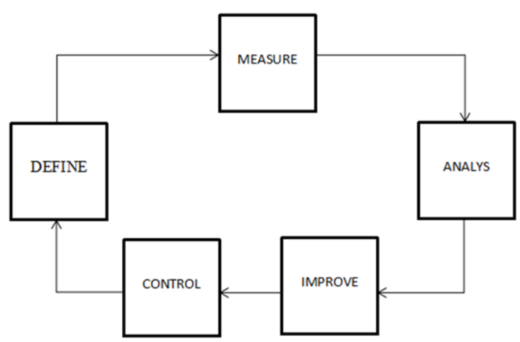


Figure 2.2: DMAIC cycle of six-sigma methodology

2.5.5 Literature's on Companies Implemented Six-Sigma

Cost et al., (2017) conducted study in an industrial environment at Continental Mabor, a tire manufacturing company located in Famalicão, Portugal. The main objective of the study was to improve the extrusion process, which is responsible for the production of two tire semi-products by using the tread and the sidewall extrusion process. The study was subsequently initiated through the application of the DMAIC cycle of Six Sigma methodology beside review of the literature from different published books and scientific articles.

Under DMAIC cycle they used a different tool that includes project charter, Gantt graph, SIPOC diagram (Supplier, Inputs, Process, Outputs, and Customer) to establish problem definition. The second stage (measure) was carried out by measuring process performance through a qualitative data collection plan. In the third stage (analysis), one used tool (Pareto, Ishikawa diagram) to determine the root causes of the problem. The fourth stage comprised the implementation of improvement actions aimed at eliminating the causes which had been identified previously. Lastly, during the control phase, the process was monitored and one proceeded with the quantification of the impact ensuing from the implemented actions (Cost et al, 2017).

According to Cost et al., (2017) the production system consists of five sections. However, they found that mixing, preparation where the extrusion process is located that has seven extrusion line (namely, E01, E02, E03, E04, E05, E06 and E07) and construction departments are the most relevant for this study. The non-conforming material generated during extrusion process is called work-off, since it is later reused which is considered as defect in this study.

During the implementation of DMAIC cycle Cost et al., (2017), drawn up project chart which identified and establish the objective and also scope and time involvement. They also drew Gantt graph using six-month data that collected from the company. SIPOC diagram was drawn which shows the process and relevant entities for the process.

At the measurement phase they collected 30 weeks' data which includes recorded of rejected materials during the occurrence of setups and disturbance in both type of extrusion process. The percentage of non-conforming materials (work-off) generated and ensuing from the occurrence of setups and disturbance are setups (5%, 10%), disturbance (4%, 3%), samples (1%, 1%), returns (3%, 5%) and acceptable pieces (87%, 74%) respectively. After that they prioritize the analysis of disturbance using Pareto chart and they selected five major defects (disturbance for each types of extrusion process) (Cost et al., 2017).

Cost et al., (2017) analyzed collected data to determine the defected root cause using Fish- bone diagram by dividing in to two types of extrusion (treads and sidewalls) and even (setups and disturbance). From the analysis the main disturbance for tread extrusion was (hopper failure, lumps, risks and length and recipe parameters) and for sidewalls (risks, machines, broken downs, width, human failure and lumps) which had cumulative value of defects.

In case of setups they analyzed E07of sidewalls extrusion because there was high difference in work-off generated during setups between E01 and E07 which is (21Kg, 38Kg) respectively. Then they take improvement action for different steps of extrusion lines (E03, E04, E05 and E06) disturbance and E07 setup problem. They drew up control plan to monitor the process and carried out new measurement in order to validate the impact of improvement implemented (Cost et al., 2017).

In conclusion, implementing six-sigma methodology had successful output in extrusion process of tier production process in Famalicão, Portugal by reducing five tons of non-conforming materials per day which result in saving of over 165 thousand euros per annual for the company (Cost et al., 2017).

Jonny and Jessika (2012) implemented six-sigma methodology to improve the quality of asbestos roofing in Indonesia Company called PT BBI. The objective of this research was to improve the quality of Mini Harflix 14 (MHN 14) type asbestos roofing. They used DMAIC cycle to execute the research including the following tools. SIPOC was used to have better understanding on the research scope. They form control chart to measure current sigma level. Fish-bone diagram and failure mode and effect analysis (FMEA) was used to figure out the possible root cause of most dominant defects. They deployed Design of Experiment (DOE) using ANOVA method in order to improve the quality of products and finally, they recommended the company to undertake improve in order to maintain the improvement process.

From data analysis Jonny and Jessika (2012) found the following results and discussed it. The current sigma level of the process on MHN 14 was 4.19δ with 200-unit DPMO and the domain for this defect was side flat type that triggered by speeding up curing time without proper increasing temperature. Therefore, in order to avoid this defect, they increased the temperature with speeding up curing time, to do that they conducted design of experiment and they found the company need to speed up from 5hours to 4hours and the temperature should also increase to 350^0c. After improvement the sigma level become 5.02δ with 180 units DPMO (Jonny and Jessika, 2012).

In conclusion, the quality of MHN 14 type asbestos roofing was improved the quality from 4.19 sigma level to 5.02 sigma level which result in reducing defected unites by 20 through implementing six-sigma methodology (Jonny and Jessika, 2012).

Adrian et al., (2016) implemented six-sigma methodology on Romany automotive company to improve the assembly process DMAIC methodology is used to improve the performance of the assembly process. During Define phase SIPOC analysis was executed and then a Flow Chart was drawn for the process. A Pareto analysis was done on 10,000 semi-finished products from which 801 were defected, revealing that unfitting height of the rivet (319 defects). At Measure phase the characteristic (Critical to Quality) which was “Rivet Height” measured. The rivet height (assembled) dimension was 10.3 ± 0.035 mm and 20 samples of 5 semi-finished products each, in an 8-hour shift was measured. Process capability was also performed in order to detect the random character of the sample as a result p value showed more than 0.5 which indicated the sample was within normal distribution. In addition, Sigma Level short-term approximately 2.9, Sigma Level long-term was approximately 1.4 which indicated 81,000 defected rivets per million opportunities.

In Analysis phase cause and effect diagram was drawn to analyze the issue and identify possible cause of defects with combination of 5whys. As a result, improper riveting force during work placement due to the worker`s exhaustion was the root cause of the defect. Also, it has been done a FMEA analysis. FMEA a measured a rational analysis method for product reliability, process or machine used in the process by inventorying their possible modes of failure, of causes that could induce these failures, of failures effects on users, and as a result, a quantitative evaluation of damage probability to product or process or equipment functions. The recommended action by Six Sigma FMEA team was to install a device to properly control the riveting force. Also, it has been recommended that the riveting hand tool design to be enhanced, even if the needed down force is not high (Adrian et al., 2016).

To improve the riveting process, it has been decided to use a contact sensor with caution (Poka-Yoke device). Afterward analyzing four changes, an Allen-Bradley Rockwell Automation limiter was selected. This type was more compact and has a minor size, most appropriate for the riveting hand tool. When the worker put on the down force, the limiter gives visual and audio signals when the essential force has been extended, meaning that the proper rivet height is achieved. And also 5 potential cables provider were carefully chosen. During Control phase; 20 samples were measured of 5 semi finish each in 8 hours, the test indicated that the sample character was with in normal distribution. As a result, the sigma level for long term was approximately 3.7 and for the short term were approximately 5.2 with 108 defects per million opportunities. And also, FMEA was installed to properly control riveting force (Adrian et al., 2016).

To summarize, six-sigma is a process quality management method through eliminating and reducing process mistakes (defects). Defects are products those will not add value in the output of the process which results in reduction of quality of the product according to (Tekin M, 2013) six-sigma should have 3.4 defects out of a million products. Six-sigma have DMAIC and DMADV Approaches in order to improve those defects and from those approaches DMAIC is the main emphasis of the study because the manufacturing process of the company already started many years ago.

Cost et al., (2017), Jonny and Jessika (2012) and Adrian et al., (2016) implemented six-sigma in different company in order to improve the quality of products and process. DMAIC Approach was subsequently used during implementation with other different six-sigma tools including; project chart, Gant graph, SIPOC Diagram, Pareto chart, Ishikawa(fish-bone) Diagram, DOE, FMEA and Control chart. Cost et al., (2017) found the main disturbance for tread extrusion were hopper failure, lumps, risks and length and recipe parameters and for sidewalls risks, machines, broken downs, width, human failure and lumps were the main cause of defects in Portages Continental Mabor, tire manufacturing company. Finally, the implementation reduced five tons of non-conforming materials per day and saved of over 165 thousand euros per annual for the company.

Similarly, Jonny and Jessika (2012) implemented six-sigma methodology to improve the quality of asbestos roofing in Indonesia Company called PT BBI and improve sigma level from4.19 sigma level to 5.02 sigma level and reduced defected unites by 20. Adrian et al., (2016) also implemented six-sigma methodology on Romany automotive company to improve the assembly process. improper riveting force during work placement due to the worker`s exhaustion was the root cause for unfitting rivet height problem. The sigma levels for long term was improved from 1.4 to 3.7 and for the short term was improved4.9 to 5.2 and defects were reduced from 8100 to 108 units per million opportunities because of proper selection of Automation limiter and cable providers.

Generally, Six-sigma methodology used DMAIC approaches as a bassline method with other different tools based on the nature of products and processes in order to improve the defect level of different organization. besides, experience of different company showed that proper identification of defects and implementation of six-sigma resulted proportional success.

2.6 Lean Six-Sigma

2.6.1 Literature's on Company Implemented Lean Six-Sigma

Ibrahim et al., (2017) conducted their study on comparative exploration of lean manufacturing and six-sigma methodology in terms of their critical success factors. The main objective of the study was to identify the similarity and difference of lean manufacturing and six-sigma critical success factors and to compare the importance of those factors in the implementation of lean manufacturing and six-sigma methods.

They conducted online survey, before that they authenticated the survey using pilot study by two expert's feedback and advice on lean manufacturing and six-sigma method and they also tested the reliability of the survey by using Cronbach's alpha. After that the survey was distributed online for 33 expert participants on lean manufacturing and six-sigma method from different company (Ibrahim et al., 2017).

From the survey they found that 20 companies had implemented lean manufacturing, 9 companies implemented both lean and six-sigma methods and 4 companies had not implemented both. They also found that from survey 36% experts opined that implementing both methodologies simultaneously yielded a rapid improvement on the process, 19.4% said that implementing both methods simultaneously increase customer satisfaction, another 19.4% stated that there was lack of improvement when implementing both lean manufacturing and six-sigma methods separately, 22% of experts said simultaneously implementation were improved safety, sustainability and time saving. Other 2.7% of the total the total experts said implementing simultaneously improve in scale Ibrahim et al., (2017). Some study said that implementing both methodologies may be difficult especially in SMEs because they have limited resources. However, some had success in sequential implementation of lean manufacturing and six-sigma method.

They compare 13 critical success factors related to lean manufacturing had six-sigma method using welcoxon signed rank test (which repetitive measures such as the importance of the same critical success factors in lean manufacturing and six-sigma method. The most relevant factors were top management commitment and support, linking the method to supplier, skills and expertise, linking the method to the customer, reward system and project management skills. They said that those factors had the same level of importance in terms of implementing both lean and six-sigma methods (Ibrahim et al., 2017).

They found significant difference between lean and six-sigma methods for some critical success factors including employee involvement which was crucial factor in lean manufacturing than six-sigma methods because in lean manufacturing all members of the company must committed for implementation however in case of six-sigma methods only selected members who had been trained involves, the second factor was communication which also had significant success factor on lean manufacturing than six-sigma but effective communication ensures successful implementation of six-sigma method, the mean ranking value of cultural change had higher importance for lean than six-sigma method this may be because cultural change is very challenging for lean manufacturing.

Understanding tools within the methodology for employee on shop floor was also another critical success factor that has higher importance in lean than six-sigma. The importance of remaining factors including understanding tools and techniques within the methodology by employees than perform jobs in office, linking the method to business strategy and linking the method to human resource were also significantly different between lean and six-sigma

According to Ibrahim et al., (2017) most company involved in the study implemented lean manufacturing successfully and the critical success factors were top management commitment, cultural change, education and training, communication, employee involvement and linking the method to the business strategy. And for six-sigma top management commitment, communication, skills and expertise, and education and training were very successful critical success factors for the company that implemented six-sigma method successfully.

In conclusion, this study provided new insight in the implementation lean manufacturing and six-sigma on how to get start and where to begin implementation of lean manufacturing or six-sigma method or integration of both methodologies based on the organizational capability of the organization in terms of critical success factors for lean and six-sigma methodologies (Ibrahim et al., 2017).

In addition, this study identified the most important critical success factors for the company that had successfully implemented lean manufacturing and six-sigma method which will provide guidance for the enterprise that lack the capacity to implement both methodologies simultaneously.

Saja et al., (2015) conducted a systematic literature review on 37 different and top papers regarding lean six-sigma (LSS) methodology. The main objective of their study was to explore the most common themes within LSS in the manufacturing sectors and to identify gaps in those challenges that may be preventing users form getting the most benefit from the methodology. They use systematic review which is “a systematic, explicit, comprehensive and reproducible method for identifying, evaluating and synthesizing the existing body of completed and recorded work produced by researchers and practitioners” (Transfield et al,2003).

They used papers from 2000 to 2013(screened out based on the first title and the abstract they needed as a criteria), they also followed approach to review those papers including develop research protocol. They selected studies depend on research criteria they established. From those studies they extracted relevant data and analyzed using quantitative or qualitative or both techniques. The most common themes they emerged in the literature were benefits, motivation factors, limitation and impeding factors (Saja et al, 2015).

As a result, the number of articles regarding to LSS methodology was quite low in manufacturing sectors compared to other sectors such as health care, nevertheless thee study indicated an incremental growth trend since 2003. The analysis of LSS benefit in manufacturing sectors showed that more than 50 benefits being identified such as identifying different types of wastes, developing employee’s moral towards creative thinking and reduction in work place accidents. The most common tools used in the study were C and E analysis, VSM, 5S, DOE and Pareto chart under DMAIC method because “DMAIC is the solid bases for LLS implementation.” They said that those tools were common because “those tools are simple to use and they do not contain any statistical equation or formula” (Saja et al, 2015).

From the analysis of motivation factors for LSS implementation Saja et al., (2015) found 17 different factors that motivated manufacturing sector to apply LSS in their organization. They said most of the organization motivated to increase customer satisfaction or to reduce cost and to save hard cash to the bottom line. They also found 9 fundamental limitations and some impeding factors for successful implementation of LSS methodology in manufacturing sectors. The following table shows the most common and top five factors for all LSS challenges they found.

Table 2.2: top five common factors of LSS themes (saja et al, 2015)

s/no	Benefit factors	Motivation factors	Limitation factors	Impeding factors
1	Increased profits and Fanatical saving	Change to competitive Position in the market or to stay in the competition of international markets	The absence of clear guide line for LSS In early stage of Implementation	Time consuming (it takes long time to fully implement)
2	Increase customer satisfaction	To increase customer satisfaction	Lack of LSS Curriculum	Lack of Resource
3	Reduce cost	Attraction and loyalty	Lack of understanding the Usage of LSS tools and techniques	Unmanaged expectation
4	Reduce cycle time	To improve product quality	Lack of road map to be followed	Lack of awareness about LSS benefits in business
5	Improve key Performance metrics	To improve manufacturing operations	The limitation of practical Applications of LSS Integrated Framework	Lack of Tanning or coaching

According to Saja et al., (2015) 50% of reviewed papers showed significant increase in saving and bottom line up to 3 billion dollars in some cases, decrease cycle time significantly by an average of 25-50 percent and lead time was reduced from 180 to 40 days, inventory and wastes as well as percentage of production defect also decreased.

In conclusion, systematic review was very interesting and helpful regarding to identify the most common challenges in implementing of LSS methodology for manufacturing sectors. Also, the tool used during implementation included DMAIC method with different other tools such as C and E analysis, VSM, 5S, DOE and Pareto chart (Saja et al, 2015).

Timans et al., (2012) investigated implementation of LSS in SMEs in Netherlands. Survey study and case study were conducted in order to present the overall picture of LSS implementation and to explore critical success factors and impeding factors for implementation of LSS. During the study Timans et al., (2012) analyzed the current status of LSS implementation in Netherlands SMEs, identified and ranked critical success factors and impeding factors and managed to sorter how those factors interpreted in to Practice and how the organizations cope with the impeding factors in their day to day Practice.

Questionnaire was prepared and distributed to 1500 Netherlands SMEs and case study was conducted on six companies. 198 companies were responded to the questionnaire and from those companies 106 were selected based on selection criteria which were included the company had implemented lean and/or six-sigma manufacturing methodologies? can the company give information on their company's strategic objective and Maine drive from their customers? Based on the knowledge and application of quality improvement methods, tools and techniques in LSS project and based on critical success factors and impeding factors to LSS implementation (Timans et al., 2012).

As a result, 63 companies were implemented lean, 42 were implemented lean and six-sigma and only one company was implemented six-sigma. 12 critical success factors were identified from survey and case study. From those factors Timans et al., (2012) prioritized as linking to the customer, vision and plan statement, communication, management involvement and participation rank accordingly. In addition, they also identified personal LSS experience of top managements, development of leader's soft skills and supply chain focus as critical success factors from expertise opinion. The impeding factors also priorities as internal resistance, availability of resource, lack of leadership and competing projects (Timans et al., 2012).

From the survey results and from the case study interviews direct visible impact of lean manufacturing project results was very attractive to all levels of employees, from managers to employees working on the shop floor. The results of for instance 5S projects or projects focusing on shortening the time to switch over to other products were visible and easily understandable for everyone Timans et al., (2012). Form critical success factors Understanding of LSS by management was very important. If management is convinced of LSS being important for creating competitive advantage then management should be trained at the champion level; Project team leaders should at least have completed GB-level education, and preferably BB-level. From case study research that in the SME context project team leaders should have at least 40% of their working time available for projects. Companies should design a system for project prioritization and selection, also containing standards for different projects with different time frames, from very short projects (1–5 days) to long-lasting projects (maximum 0.5 years). DMAIC or a similar structure, adjusted to the type of project, should be part of these standards (Timans et al., 2012).

According to Timans et al., (2012) impeding factors are connected with the quality of leadership and communication. They said case study organizations show different quality levels with respect to these issues; Good quality on these issues is connected to creating confidence and trust among employees in taking part in challenging improvement projects. High-quality HRM and education and training in developing soft skills as well as in the application of tools and techniques are necessary to develop the organization towards full LSS implementation (Timans et al., 2012).

In conclusion, the purpose of this study was investigating implemented LSS manufacturing and identifying and prioritize critical success factors and impeding factors through survey and case study on 106 companies in Netherlands SMEs. Linking to the customer, vision and plan statement, communication, management involvement, participation, LSS experience of top managements, development of leader’s soft skills and supply chain focus were top ranking critical success factors and priorities as internal resistance, availability of resource, lack of leadership and competing projects were impeding factors for implementing LSS manufacturing methodology (Timans et al., 2012).

Gunjan et al., (2016) conducted literature review on lean six-sigma and the objective of their study was to amplify on clarifying views, trend and importance of LSS through reviewing the published literature over multiple parameters for better understanding the research domain. The review was conducted on journal article published between 2001 and 2014 which were prominently considered as qualitative synthesis. They yielded 189 LSS articles from 58 journals from different databases. After review they proposed 8 different classification methods to analyze the literature. (Journal and publisher, year of publication, contribution of countries worldwide, research methods, research design, industrial sectors, enablers of implementation and active authors in the research) were the classification methods they proposed.

From the analysis of world website on LSS, it was highlighted that there was splitting view in terms of rang of subject areas which accost the topic. They noticed that popularity of LSS and the level of LSS development increased in the industrial world especially large organization and in some SMEs in developing countries. They also found that majority of the article showed conceptual modeling holds greater credibility and the trend was moving towards mathematical building as well as testing. They observed most advanced techniques were used for data analysis in empirical study and sequential increase in hypothesis testing (Gunjan et al, 2016).

Gunjan et al., (2016) also found that from article review the highest percentage was hold by manufacturing and engineering sectors, and almost half of those sectors were found in USA and UK, from those articles most of the were case study and conceptual models and they were also desk qualitative and empirical qualitative.

In conclusion, the purpose of the sturdy was to examine the status of LSS researches in terms of units of analysis, existing methodology employed and research topic. 14 years' articles from different databases were reviewed and analyzed by developing classification framework that had eight categories and each of them discussed and finally prioritized distribution of articles in each category (Gunjan et al., 2016).

Kumar et al., (2006) implemented LSS in an Indian automobile accessory producing company. The objective of their study was implementing LSS framework that includes integrated lean tools (VSM, 5S, TPM) and six-sigma DMAIC method to reduce the defect occurred in the final product manufactured by die-casting process to satisfy customer demand. They conducted case study to know the overall process of the production and to identify wastes available in the process and also to identify defects found in the product.

According to Kumar et al., (2006) the interest of management was in increasing customer demand that would maximize return on investment which means the management concern on the production than quality of the product which result in an increased work-in-process inventory, re-work cost, scrap and more defects (external and internal casting defects like growth, cracks, cold shot, pin hole, porosity and others) in the final products. They observed many wastes embedded in the manufacturing process and those wastes were tackled by work-in-process inventory which resulted high inventory carrying cost. They also found from voice of customer that most of customers compliant were related to crack in the final die-casting products that resulted improper functioning of automobile engine, for this reason the company decided to implement LSS framework.

During define phase the management meeting was called by top managements with senior managers of different department, engineers and operators, and they discussed about restructuring of current practice, enthusiasm and motivation among employee was investigated, the success and problem encounter during implementation were discussed, cross functional team were formed. Those team conducted observation on the shop floor and collected data associated with die-casting unit. A number of brainstorming sessions was conducted among the team members and problem of the die-casting, the size of the problem and the impact of the problem were discussed. Current state map was drawn in this phase that gave insight on the die-casting process including flow of material, flow of information, process cycle time, machine up time, number of shifts, changeover time and the percentage of defected units (Kumar et al., 2006).

At measure phase the team was divided in to two small groups and the process where defects occurred and also collected data and analyzed. For the analysis they found the maximum defects were come from the die-casting machine, de burring operation, and chamfering and threading operations. A gauge Repetitive and Reproducibility (Rand R) study was conducted to identify the source of variation in the measurement system and accuracy. The result showed 8.01% variation which was acceptable. Using this equipment, they found 0.12 defects per unit (DPU) was baseline operating capability of the company and the casting density was 2.41g/cc (Kumar et al., 2006).

According to Kumar et al., (2006) six casting defects were analyzed to identify the root cause defects and identified the significant parameters caused the defects as a result air or gas trapped inside the metal during solidification was the root cause for crack propagation. Pareto chart showed internal defects were the result of poor casting density and had high impact than external defects such as defects in the de burring, and chamfering and threading operations. The cause and effect diagram showed that the most important parameters that affected the process were piston velocity in first stage, piston velocity in second stage, metal temperature, filling time and hydraulic pressure.

Design of experiment was carried out during improve phase that used L_{27} orthogonal array, a total of 27 trials were conducted and the process parameters were optimized from A_1, B_1, C_1, D_2, E_2 to A_3, B_3, C_1, D_3, E_3 that maximized casting density. Then they implemented 5S and TPM to establish clean environment and reduce idle time of the machine and employee on the shop floor. Results from improve phase were validated by conducting confirmation test as a result the average value of casting density was 2.75g/cc and in case of 5S it insured the employee had sufficient light on shop floor, minimized idle time, time in transportation was saved, insured the health and safety of the employee. The following steps were taken by management which was periodic maintenance; collection and analysis of downtime of machine, creating an equipment maintenance team and TPM coordinator involve all employees at all level of organization and emphasizing the training program (Kumar et al., 2006).

At control phase they plot control chart used to the optimal process parameters, they exercise mistake proofing including human error, malfunctioning of machine or improper environmental condition. Those mistake proof exercises were performed to reduce number of defects occurring in the process. In order to prevent the occurrence of defects the management decided to check defects at preliminary phase, to use failure mode and effect analysis, to form cross-functional team, to share information with employees, to train people on the shop floor, to use control chart and graph at each process stage, to motivate and recognize employee's contribution, and to reward and recognize the employee involved in the project (Kumar et al., 2006).

The team evaluated financial benefits generated by sustaining LSS project as a result saving generated due to reduction in defect was estimated around 46,500 dollars per year, saving from decreased downtime was 40,000dollars per year, saving from work-in-process reduction was over 33,000 dollars per year, from standard housekeeping that resulted decreased in number of accidents saved 20,000 dollars per year. Convincing top managements, resistance from employees, resistance from managements was difficulties encountered during implementation of lean six-sigma framework (Kumar et al, 2006).

In conclusion, the purpose of this study was implementation of LSS framework on die-casting process of Indian automobile accessories producing company. After implementation the company resulted in significant change such as the company identified air trapped in metal during solidification process was the root cause for crack propagation which is the main defect in the company, the process parameters were optimized using orthogonal array that had 27 trial and 3,3,1,3,3 was the optimum result and casting density was improved to 2.75g/cc which was in required rage, finally, the company saved around 140,000 dollars per year from the implementation (Kumar et al., 2006).

To summarize, lean six-sigma is a combination of lean manufacturing and six-sigma methodology. Many researchers were conducted different studies regarding the implementation of LSS manufacturing methodology. Ibrahim et al., (2017), Saja et al., (2015) and Timans et al., (2012) were conducted systematic literature review and survey in order to present the overall picture of LSS implementation, and to explore, compare and prioritized different critical success factors and impeding factors for successful implementation of LSS manufacturing methodology. As a result, the most relevant factors were top management commitment and support, linking the method to supplier, skills and expertise, linking the method to the customer, reward system and project management skills (Ibrahim et al., 2017), The most common themes factors they emerged in the literature were benefits, motivation factors, limitation and impeding factors (Saja et al, 2015) and linking to the customer, vision and plan statement, communication, management involvement and participation, personal LSS experience of top managements, development of leader's soft skills and supply chain focus as critical success factors from expertise opinion as critical success factors and internal resistance, availability of resource, lack of leadership and competing projects identified and prioritized as impeding factors (Timans et al., 2012). In addition, the most common tools used in the study were C and E analysis, VSM, 5S, DOE and Pareto chart under DMAIC method. They said that those tools were common because “those tools are simple to use and they do not contain any statistical equation or formula” (Saja et al, 2015).

Gunjan et al., (2016) conducted literature review on lean six-sigma and the objective of their study was to amplify on clarifying views, trend and importance of LSS through reviewing the published literature over multiple parameters for better understanding the research domain. The result was showed that most of the articles were from developed countries like UK and USA and from those articles only six of them were published on food processing industries including one article published on Beverage Company. Kumar et al., (2006) implemented LSS Framework in an Indian automobile accessories producing company to improve die-casting process and satisfy customer demand. Lean tools (VSM, 5S, TPM) and Six-Sigma DMAIC method, DOE and mistake proofing were used in the framework. air or gas trapped inside the metal during solidification was the root cause for crack propagation (problem in die-casting process) and the most important parameters that affected the process were piston velocity in first stage, piston velocity in second stage, metal temperature, filling time and hydraulic pressure. As a result, the process parameters were optimized to improve casting density from 2.41g/cc to 2.57g/cc, control chart used to the optimal process parameters, they exercise mistake proofing including human error, malfunctioning of machine or improper environmental condition and after implementation the company saved around 140,000 dollars in a year.

Generally, many developed and some developing countries implemented LSS methodology yet, very few were succeeded because of improper identification and selection of tools, themes and critical success factors. Different literatures in this topic conducted in many countries shows properly selected and prioritized tools and factors as general. Implementing this methodology is difficult unless selection and prioritization of tools and factors is based on the nature of the process.

2.4 Summery of Chapter and Identified Gaps in the Literature's

Implementation of lean manufacturing is very important for many manufacturing industry nowadays because as explained above lean manufacturing is a process/philosophy used to eliminate wastes found in the process of manufacturing but organizational culture of the organization should change and also, during implementation using different appropriate tools such as value stream mapping, 5s, kaizen/continuous improvement, standardization and other tools of lean would lead to success of the implementation.

Six-sigma is another part of this study which is a method for improving of the quality of product or process. From the literature reviewed regarding six-sigma the researcher used DMAIC cycle as a method of execution of the improvement. Beside that they also used different tools like Pareto chart, SIPOC diagram, project charter, Gantt graph, ishkikawa diagram, Fish-bone diagram, failure mode and effect analysis and others. After implementation they found good output which implies implementing six-sigma would be possible in different industry.

Lean six-sigma is an integrated methodology of both lean manufacturing and six-sigma method, the integration of the two systems can achieve much better results than either system can achieve alone. While, Lean strategies play an important role in eliminating waste and non-value-added activities across the organization, Six Sigma, through the use of statistical tools and techniques, takes an organization to an improved level of process performance and capability.

LSS implemented in many organizations around the world, for successful implementation identify critical success factors, benefit factors, motivation factors, limitation factors and impeding factors are very important. Most companies using the integrated approach apply basic Lean tools and techniques at the beginning of their program, such as current state map, basic housekeeping using 5S practice, standardized work, etc.

As discussed above many companies implemented lean manufacturing, six-sigma methodology and lean six-sigma manufacturing in different time but there were gaps which are listed below: -

Their study does not cover all sectors which includes process industry's including beverage industry that was very important for this research especially when there is shortage of related studied journals (Abdullah A. and Patrick M, 2018).

They used limited number of lean tools including VMS, 5S, Standardization work and kaizen which was not enough to evaluate the success of lean manufacturing in all car dismantling companies. By increasing number of tools, they would increase the efficiency and output of the company (Islam et al., 2018).

They did not identify the sigma level of the extrusion process which would be good to know current states and used as a reference for improving the next level of sigma (T. Costa et al., 2017).

They conducted systematic review only on the paper published that showed successful implementation of LSS methodology but if they were included paper that implied failed of implementation it would give a better outcome than they got (Saja et al., 2015).

They investigated, identified and prioritized critical success factors and impeding factors for implementation of LSS. But they did not developed framework for the case companies with the consideration of critical success factors and impeding factors (Timans et al., 2012)

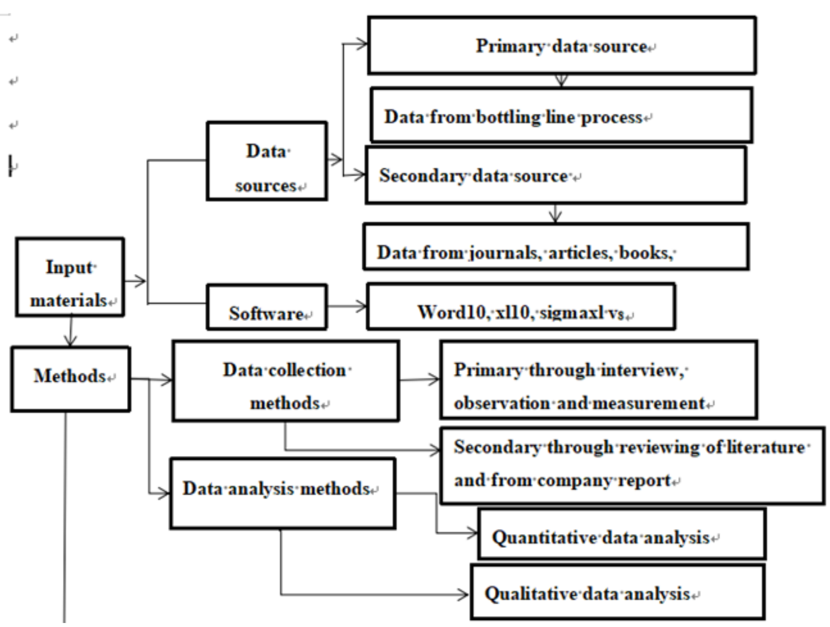
Chapter Three

Research Design and Methodology

3.1 Research Design

Burns and Grove (2003) define a Methods and Methodology as “a blueprint for conducting a study with a maximum control over factors that may interfere with the validity of finding”. Parahoo (1997) also describe research design as “how, where and when data are collected and analyzed”. The study used an interview with managements, shift coordinators and operators to know about the knowledge, experience and understanding of lean six-sigma methodology and other information regarding the company especially, the bottling line process. And also, observation at Brewery Company was undertaken.

According to Burns and Grove (2003) descriptive research “is designed to provide a picture of situation as it naturally happens”. It may be used to justify current practice and more judgment and also develop theories. For the purpose of this study descriptive research was used to obtain a clear picture of employee’s operation, flow of materials and other tasks on the bottling line of BGI brewery industry and also their opinion on implementation lean six-sigma methodology on the line



Procedure

-Literature review (books, journals, articles, websites screen out relevant literatures and books)

- review of relevant literatures

- visit BGI Brewery Company and prepare interview questions

-conduct interview, observation and measurements

- collect data from interview and observation and measure different para maters on the bottling line (cycle time, batch, speed of operation) and desk review of company record data (yearly produced beer)

-analyze data (takt time, uptime, SIPOC, current VSM, sigma level of the process, Pareto analysis and wastes on the line)

- identify critical success and impeding factors for implementation

-Discussion of results from analysis

-development of LSS framework for BGI company

- write down the implementation procedure for the Framework

-conclusion, recommendation and future works

Figure 3.1: Research Methods and Procedures

3.2 Research Methodology

The study used both qualitative and quantitative methods from primary and secondary sources. Data collection was conducted in two ways the first one is from documented report of the bottling line process and the second is during observation, measurement and interview.

3.2.1 Data Sources

3.2.1.1 Primary Data Source

Primary data was obtained from the original source of information. Those data sources are working environment of bottling line process and other process in the company observation through real time picture; company employee including managements, operators and other employees through interview and focus group discussion.

The population of the study was BGI brewery employee in Addis Ababa city which is headquarters of the company. The sample was selected randomly form different section of the company bottling line process. Totally, 13 employees were responded to the interview those included 1 top manager.

1 production manager, 1 quality control manager, 2 shift coordinators and the rest were operators and line observers.

3.2.1.2 Secondary Data Source

Review has been conducted to collect secondary data including recorded documents regarding bottling line process and also, literature review related to lean manufacturing, six-sigma method, and lean six-sigma methodology has been secondary source of data. Journal, articles, books, websites and another source were considered.

3.2.2 Interview, Observation and Measurement

Interview was conducted on focus group using an interview with semi-structured questions. The interview questions have 8 different categories including general information about methodology; communication involvement and employee skill; device and standardization; bottling process and other. The selected sample was 26 interview respondents, 12 observations and 30 measurements. However, the collected data indicates 13, 10, 30 responses from interview, observation and measurements respectively.

The measured data included number of bottles introduced to the line, number of defected and rejected bottles, cycle time of different machines on the line, speed of machines, downtime, uptime and others. Data from observation included overall operation conducted in the company, process flow of the bottling line, working principle of different machines on the line, workshop arrangement and other.

3.3 Data Collection Methods

Data collection methods were focused on primary and secondary data collection on both quantitative and qualitative data sources.

3.3.1 Primary Data Collection Methods

Primary data are both qualitative which including observation and interview questions, and quantitative data including measurements and also interview questions. Observation is connected to data collection and the sources for observation are visiting different department of the company, recorded data, interview and direct observation of the bottling line process. Researcher used lean tools to clearly understand the process of bottling line besides using observation method as one of tool for collecting data. Data also collected through interview; during interview both qualitative and quantitative information about the company bottling line process was collected. And also, data was collected through measurement.

The response rate for proposed data source was indicated that interview resulted 50% of response among the respondents; observation resulted 83.4% of respondents and measurement resulted 100% of respondents.

Table 3.1: planned, actual and success level for response of the study

Instruments	**planned**	**actual**	**Success level**
Interviews	26	13	50%
Observations	12	10	83.4%
Measurements	30	30	100%

3.3.2 Secondary Data Collection Methods

Secondary data is obtained from other source like data collected by someone other than user. Secondary data could be internal like recorded data and external source of information. Literature review, review of company report has been conducted. Literature review was conducted using different database like science direct, Emerald, Research Gate and other source of materials. The search was based on title, abstract, success of implementation and developed framework in different company. Researcher reviewed more than 125 articles and journals and, screened out to exclude unrelated articles. Finally, 36 relevant articles which were related to the objective and research model were used in the study.

3.4 Methods of Analysis

Data analysis means to organize, provide, structure and draw meaning. Data analysis was conducted after data was collected through interview, observation and measurement from BGI Company bottling line process.

3.4.1 Quantitative Data Analysis Methods

Quantitative data was obtained from both primary and secondary data sources and analyzed using different lean tools and six-sigma methods and also Sigma-XL V8 software was used.

3.4.2 Qualitative Data Analysis Methods

Analysis of qualitative data is an active and interactive process (Polit et al, 2001). Interview, observation and company reports were used in qualitative data analysis. During the analysis of qualitative data different lean tools and six-sigma methods with different software like Sigma-XL V_8, Microsoft XL and Microsoft word 10 were used. This software analyzed the current state of the bottling line process regarding both lean and six-sigma methodologies and also gives clear picture of the process.

3.5 Ethical Consideration

Ethical clearance was obtained from School of Mechanical, Chemical and Material Engineering, Adama Science and Technology University. Official letter was written from School of Mechanical, Chemical and Material engineering to BGI brewery manufacturing industry. The purpose of the study was explained. There is a plan to give the copy of the research to the company so they will see and consider it to implement. In addition, the data collected from the company will share to other researchers by permission of the company.

3.6 Dissemination and Utilization of the Result

The result of this study will be presented to Adama Science and Technology University School of Mechanical, Chemical and Material Engineering and also planned to present to BGI brewery industry. The result will also be availed by publication and online presentation in Google Scholars.

Chapter Four

Bottling Line Process

4.1 Introduction

BGI Brewery bottling line is one section of the company were produced beer is bottled and ready to transport to the customers. The bottling line has 8 main process including; depalletizing (introduce 42 crates of empty bottles to the line), pick 96 empty bottles for 4 crates using deca machine, washing process (washing of empty bottles), filling and crowning process, pasteurizing process (boiling bottled and crowned beer in order to stop fermentation), labeling process (branding and barcoding), pick 96 bottled beer from the line and put in in crates using inca machine and lastly, palletizing process (pick 42 crates of bottled beer and put it on pallet and make it ready to transport for the customers).

The brewery company also has its own laboratory to control the whole process from the quality of barley received from supplier to the quality of beer made in the process of beer production and also to bottling of produced beer to create the better quality possible in all products.

4.2 Obtained Information

Interview questions are classified in to 8 categories and each classification has different number of questions. As maintained in chapter three planned number of interviewees was 26 and number of actuals was 13 interviewees including, top and middle managements (the manager of the company, quality control manager, production managers, store manager and marketing manager), shift coordinators and operators from bottling line process. Table4.1 reports the number of questions in each category.

Table 4.1: categories and number of participants in interview

Categories	**Number of questions**
General information	17
Communication, involvement and skill of employees	11
Judoka, device and standardization	10
Voice of customer VOC, CTQs	9

Bottling process	14
Defect, six-sigma, stock and material	12
Stock of final product, JIT, OEE	12
5S, VSM and Changeover	17

The information obtained from different ways during interview and observation of the company was explained in this point. The visit to the production plant, and the interpretations based on the interview questions and how the company works explained.

BGI includes another brand in the company called panache beer with lemon test and low alcohol content. The bottling line receives produced beer in hectoliter from beer production team and delivered bottled beer to the customers, the amount of beer produced per year is around 1392000 hectoliter of beer and 12000 hector liters is belonging to panache. Compare St. George beer to panache it is very small and produced very few days for this reason panache was not included in this thesis. The product per year is 131749684 bottles of beer; number of sold bottle shows the size of the company. The company has one bottling line and it also has its own laboratory which makes the work faster. The next shows the number of empty bottles introduced to the line and amount of bottled beer produced.

Table 4.2: received empty bottle and produced bottles of beer for a year 2016/17

Months	**Received empty bottles**	**Produced bottles**
January	14238720	12884551
February	14192640	13137688
March	11369088	10631288
April	11980800	11211053
May	14726016	13638184
Jun	12516480	11588904
July	12651264	11543924
August	10012032	9042776
September	1195776	1126430
October	13590144	12642720
November	12167424	11417616

December	13510656	12641645
Total	**142151040**	**131749684**

4.2.1 Philosophy

The researcher observed that, the company does not implement lean manufacturing or six-sigma philosophy. Only one person about lean and six-sigma from all the company workers that is production and quality department supervisor and from bottling line process no one knows about both methodologies. the company philosophy is focused on delivery always, working with big inventories as it could see in the raw material storehouse and this inventory is because of two reasons the first is because of bureaucracy that takes a lot of time to deliver the raw material to the company and the other is because of shortage of green currency/dollar (to overcome the problem they order lots of raw material once). In the process of the company, there are some techniques which are based on common sense and belong to lean philosophy too and they implement.

In the brewery sector the main raw material is barley and in the case of BGI brewery the problem is the company has high inventory because of two reasons mentioned above (i.e. the company store for four months in case of those two problems). For this reason, they do not follow just in time production but with available resources.

They produce beer according to the production plan received from planning team that is from customers and within 24 to 48 hours the product is delivered to the customer. Some times because of delay of raw material delivery lead time is occurred means there is no beer to the customer demand during this time the company gate beer from his branch in Hawasa and Kombolcha.

Figure 4.1: Inventory of empty bottle in side packaging area

4.2.2 Organization and Operators

The communication between departments is open and both formal and in formal and between top managements and operators is open and informal. The company has interest in the opinion of the employees and they collect information and suggestion every day from the production plant. So, the employees are somehow involved and encouraged with the company and they would be ready if the managers wanted to develop a lean production.

Most operators have lean manufacturing notions because they carry out tasks about maintenance, cleaning, solving problems and they pick the bottles when the defect occurs to be reprocessed. Also, the operator receives the production plan from team leaders to not produce more than what is expected by the predicted demand but when the order comes from the planning team it ordered for 24 hours and most of the time the fourth shift is notified about the demand and were to stop.

They are responsible of its production and their own machines ‘maintenance (when the problem is manageable by them other ways, they inform to the mechanic of the shift leader) and preventive maintenance. As a result, the personnel have the basis for a lean six-sigma implementation according to the topic. They have routines which help to reduce the losses of time and reduction of defected bottles but without standardization of the tasks. Therefore, the activities can be improved by lean techniques.

4.2.3 Production Planning

BGI has a production plan to produce depending the predicted demand, so it does not follow a just in time philosophy, because the company don’t wait for the demand to produce the unit that the customer desire. The brewery, based on its experience, generates their forecasts that are usually regular with a seasonal increasing in holly days like Ethiopian New Year, Christmas, and ester. It is the way they plan the production.

They have number of big tanks to store big quantity of beer for some weeks until it ordered to the bottling line, so, they have to plan the bottling to this beer during these weeks to not deteriorate the quality of beer. After the production of beer, the process of bottling is more of just in time production. After the beer is stored in the tanks the company wait for the order to pack the beer in to bottle and this is conducted by receiving customers demand and ordering the demand to packing team.

4.2.4 Customer and Demand

Regarding the customer approach, the brewery knows what the customer opinion from several ways, but they do not have specifically surveys for them to know more detail about other aspects of the purchase. They know that customers are satisfied with a very high quality-price opinion. BGI is focused on their tastes and suitable for all human they said it is what customer appreciates more.

According to the director of production, the most important factors are the delivery on time and the price for both side of the business, brewery and client. From the customer's opinion, the company does not have any special way to know the important factors. Only sales reports give them a general idea, but in the interview more important factors related with delivery in time, discount was considered. The customers are wholesalers, distributor, supermarket, shops, groceries, hotels, and when they need the product the brewery should have the product for the date. This fact generates influence in other factors because it keeps good relationship, creates benefits in short and long term, and builds the reliability of the company.

4.2.5 Stock

One of the problems for a lean six-sigma methodology implementation would be the big stock that they have. At least, they always have work with 4 months of stock of barley and minimum of one-month stocks of other materials and they order when they achieve the security stock, which is four-month stock of barely and one month of other materials taking in to consideration that they can produce more than 12884551 bottles of beer every month, the quantity of raw materials is very significant other than the stock of the final beer bottles. The space that required is huge.

They have big plant where they store materials and they also have a store out of the company for the raw materials and bottled beer and this is a cost for the company and a 'waste' from the lean perspective. All of these materials are bottles, crown, chemicals, adhesives, labels (both neck and body) and others other than barley.

Some of the materials are purchased form home grown company and other are imported, including 60 percent of barely, chemicals, adhesive tape, and others are imported from other country. Similarly, 40 percent of barley, crown, bottles and others are ordered from different Ethiopian Factory and Ethiopian Farm (Assela).

A good thing is that the beer production is take place next door to the bottling line and the stock is replenished when ordered and also, raw materials like bottle, crown, labels, crates is next to machine which reduced movement of operators.

4.2.6 Wastes

Wastes consider in the company are underutilized workers because most of the processes are automatic and if there is no problem or changes in the setting some workers are waiting for the next activity because the machine do not have exact speed.

The other wastes considered that happening in the bottling line is over processing or re-work, inventory of empty bottles between processes, waiting time between processes. The rejected bottles are continuously fixed and put them in the process again when it is possible because of this unnecessary movement of operators also happened. One of the operators’ tasks which author observed is that they check the bottle and put it depending on the defect, in the entrance of machine which is before washing machine. The other waste is waste of resource material like waste of beer, labels chemicals crowns, broken bottles those cannot reprocessed.

4.2.7 Control Device

BGI bottling lines applies many Jidoka practices from Lean manufacturing. During the bottling process there are electronic devices or sensors which control that the activity is performed correctly. It is a way to reduce the defects after the stages. These controls also do monitor values; they register data of the attributes.

The lines run automatically because they also have sensors to detect that there are bottles in the entrance of the previous belt. Consequently, the machines stop or reduce the speed when they do not detect enough bottles to fill the machine. Thanks to that, the machines can auto control the different speed between stages because not have the same cycle time and for this reason the line works with intermediate stock to avoid the down times and stoppages.

There are more sensors which make that only products with the right specifications could pass the step. So, main defect is detected during the processes. These sensors are explained before and are the tools to control at the exit of the processes. They let the Control system knows what bottles reject. In addition, the operators have the power to stop the line when the problem requires it or the responsible consider it.

All the machines have a display where you can get information about the bottles performed in the stage, speed or bottles per hour. Also, in each line, there is a display on the computer to monitor the temperature of the beer, pressure, valves of beer pipes and many other parameters.

The company has one bottling line which has been studied in this paper; the first control is called EBI (Empty Bottle Inspection) which is placed next to washing machine. This machine inspects defected and rejected bottles which uses photo sensors that inspects dirty, water, labels, caustic soda in side bottle and cracks which are invisible by necked eyes. In the control display shows number of rejected bottles and rejected bottles. The next control devise is placed after filler machine called FBI1(Full Bottle Inspection) which controls under fill of beer in the control machine is designed for both under fill and overfill but the company only considers under fill and the display shows that if the beer is under 327ml the machine would reject it.

The other control device is suited after labeler machine and called FBI2 which controls under fill that passed FBI1; check the label if the bottle is not labeled both to the body and the neck the machine would reject it. And the last control device is placed after inca-deca machine which operates by holding and putting 24 bottles in to the crate called FBI3 which controls the crate wither it is full or not if the crate has number of bottles less than 24 the machine rejected it but it would not consider as waste because the operator fills the remaining bottle and send to the palletizer.

In the next diagram the 4 control places appear represented in the process. These are the 4 automatic controls after the 4 processes more important for the final quality of the product.

Figure 4.2 shows how the employees operate when the bottles are rejected. When the bottle is not correct, if the bottle has a beer inside, the crown is removed and the beer disposed to the waste rejection pipe. Afterwards, the empty bottle is put on the line again, before the washing machine to start again the process.

4.2.8 Lean Efficiency

In the bottling plant, they do calculate specific parameters to control the efficiency of the machinery, employees, down times, and so on. They know an idea of the time and analyzing the time because time is important issue for them. The producers know that they work under a lower speed for many reasons.

There are fewer problems with the alignments of the belts, they have intermediate buffers between machines and it reduces the efficiency and productivity values. On the other hand, if the idea is to implement Lean manufacturing concepts, they should start step by step taking times, standardize the activities and steps to follow, increase the loading times of the machines and reduce buffers and other lean concepts**.**

4.2.9 Six-Sigma Static Process Control (SPC)

The last important topic is about statistical process control (SPC). BGI use statistical methods to analyze some of the processes like machine efficiency. The brewery collects information from all stages of the line, and treating some of data, using any statistical tool, checking the values of all the attributes necessaries.

The information that they mainly keep to control are values of variables of the process, the speed production and bottleneck of the process. With this information, they pay attention on the limits and the value. The product must have all the variables inside the specification limits instead of going further with SPC and control how the behavior of the variables is.

Therefore, they do not develop a Six-sigma philosophy on reduction of defects or variability because they register this data, but they cannot analyze them. The author saw that they have control device on the washing, filling, pasteurizer, labeling, inca-deca machine which informs the operator about the number of bad labels in that batch and showing the last statistics of the units and the percentage of the total bad bottles from the total. And also, they do not control the defects in the production.

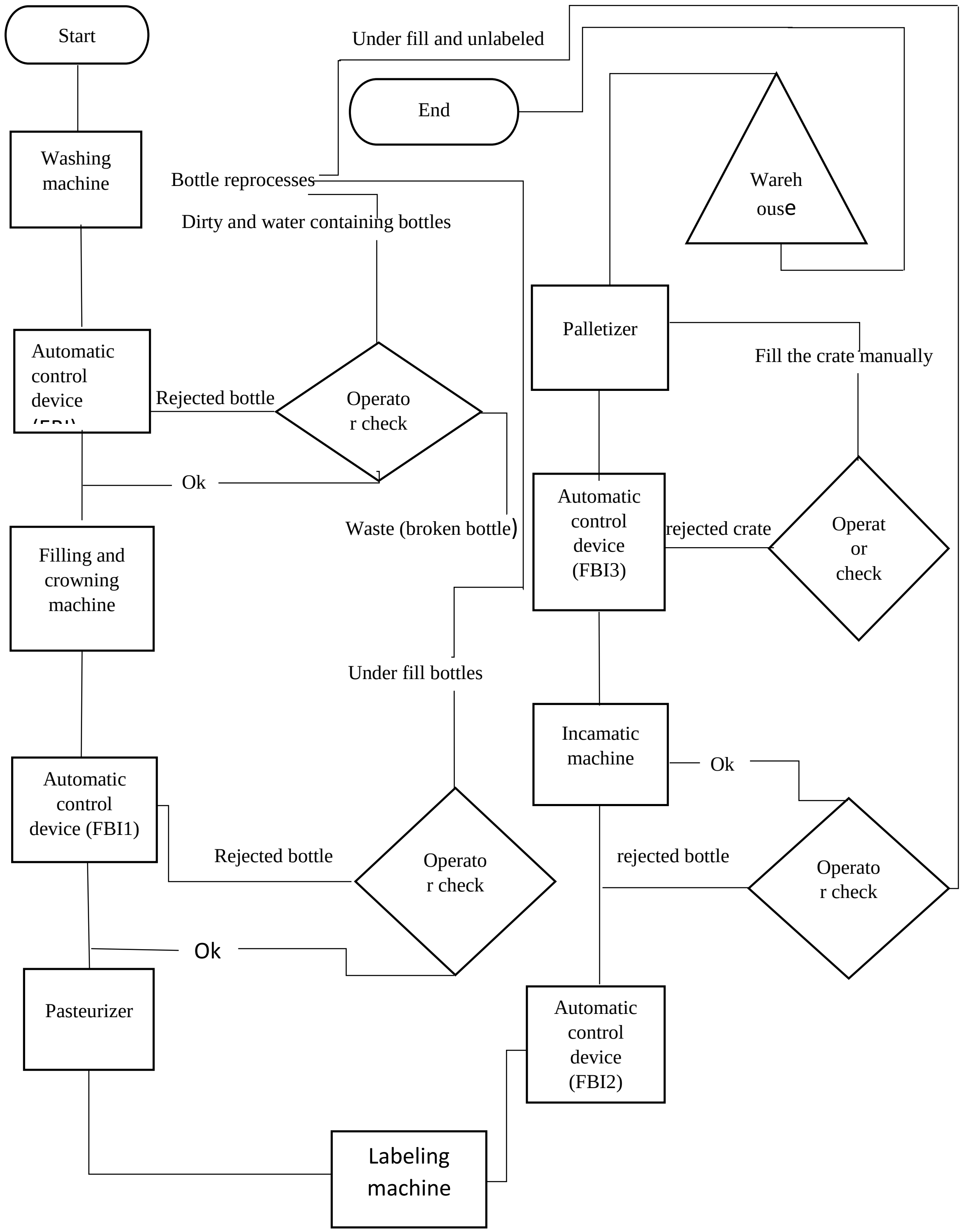


Figure 4.2: Bottling and Packaging process and the control detectors of the line

4.3 Collected Data

4.3.1 Bottling Line Process

Once all the information obtained from the company has been explained, during the visit it was possible to take data to analyze the current situation of the processes. The study is about the bottling line. The main symbols are going to be explained based on the value stream mapping.

The following Processes data were collected and analyzed from the bottling line: -

C/T (s) = Cycle Time (time since an item starts its manufacturing process until it finishes)

Speed (bottles/h) = Rhythm of production of the machine or process.

Batch = Number of bottles inside the process at the same time.

TAKT = Each Takt time a unit it is processed and comes out of the process.

Uptime (%) = OEE (Availability).

These values for the VSM were collected during the second visit. All the speeds, times, quantities, correspond to the way that the process was working.

Table 4.3: speed, cycle time and batch for each machine

Machine vs parameter	De-palletizer	Deca-deca	washer	filler	pasteurizer	labeler	Palletizer
Speed (bt/hr)	45,000	42,500/ 40,000	38,500	30,000	36,500	32,000	45,000
Cycle time	360sec	5sec	2400sec	3202sec	2679sec	3300sec	198sec
Batch	1152	96	14508	13268	13028	12832	1152

4.3.2 Defected and Rejected Bottles Data

The second interest was to collect information about the rejected bottles. Based on the improvement of the quality in the company, the reduction of rejected bottles involves an improvement on this issue. The idea is to know what control rejects more bottles to pay attention on that defect.

The defects that occur more often, obviously, are more interesting for the quality improvement and to create a more robust product, which means the product tries to be always with the same quality. The strategy is focus on the main mistakes before others that are working well currently.

Table 4.4: defected and broken bottles on the process line of year 2016/17

Months	**Rejected empty bottles**	**Rejected full Bottles**	**Broken full bottles**
January	562668	353976	140380
February	472224	444456	138272
March	386088	212136	112216
April	425688	222408	121651
May	662424	255312	170096
Jun	474192	273768	171480
July	530712	379848	129484
August	512856	324840	103912
September	42456	15816	11074
October	560376	223848	141456
November	425352	173568	128688
December	498096	209448	153643
Total	**5553132**	**3089424**	**1522352**

The above table shows information empty bottle received and bottled beer produced. In the line collected data during several days. From the table, the defects and rejected bottles were studied during the production of 131749684 bottles, the line runs at around 35000 bottles per hour theoretical speed but the final performance is less due to the buffers between machines, stoppages, breakdowns and other unexpected problems.

It is considered necessary to be commented that sometimes a mistake occurred in the line during the data collection because some of the rejected bottles in the machines were rejected but the bottles were correct. It happened at that the filling, and labeling process also

Table 4.5: non-value-added time between processes

Processes	Non-Value-Added Time
De Palletizer	360 sec
Process between De Palletizer and Deca Machine	360sec
Deca Machine	5sec
Process between Deca and Washing Machine	780sec
Process between Washing and Filling Machine	225sec
Process between Filling and Pasteurizing Machine	1289.2sec
Process between Pasteurizing and Labeling Machine	211sec
Process between Labeling and Inca Machine	311sec

4.4 Summery of Chapter

In summary, BGI Ethiopia Brewery Company found in Addis Ababa produces St. George beer and panache (lemon flavor and low alcohol content). The company manufacturing process is conventional and focused on satisfying the market demand and they produced beer when the demand is come from the customer and they also produce and store in different warehouse in the city. The company always keeps four-month stock of barely which come from abroad (40%) and from Assela (60%), and one-month stock of other raw materials like; chemicals, crown, labels and others. The communication between top managements and other employees of the company is open, formal and informal, team managers, shift coordinators and other employees are openly asked for their opinion and involves in decision making regarding the bottling line process and other issues. The bottling line process uses some SPC tools and control device to control the production process and record data regarding the line including cycle time and speed of different machines, batch of the operating machines and the process, produced bottles rejected and defected bottles, downtime and other information’s.

The total production of the company during 2016/17 was 1392000 hectoliter beer from that 131749684 bottled beer was sold and 10164908 defected and rejected bottles were found on the bottling line process. The bottling line process has eight clearly visible wastes on the line including; inventories, unutilized workers, waiting time, over production, over processing, defects, unnecessary movement of workers and waste of resource materials.

Chapter five

Data Analysis, Result and Discussion

5.1 Data Analysis and Results

Once all data from bottling line were collected data analysis is conducted to know the current status of the process as follow: -

5.1.1 Takt Time

TAKT = Each Takt time a unit it is processed and comes out of the process.

Takt time calculated as follow: -

$$takt\ time = \frac{cycle\ time}{batch}$$

The following table shows takt time for each machine in the bottling line

Table 5.1: Takt time for each machine (second per bottle)

Machines	De palletizer	Inca-deca	washer	Filler	pasteurizer	labeler	palletizer
Cycle time/sec	360sec	5sec	2400sec	3202sec	2679sec	3300sec	198sec
Batch/bts	1152bts	96bts	14508bts	13268bts	13028bts	12832bts	1152bts
Takt time(se/b)	0.3125se/b	0.052se/b	0.165se/b	0.241se/b	0.205se/b	0.257se/b	0.3125se/b

$$\text{monthly takt time} = \text{avilabel working time}\frac{\text{per}}{\text{customer}}\text{demand per month}$$

$$= 20.075\text{days} * \frac{22.50\ \text{hours}}{13137688\text{bottle/month}} = 0.1234\ \text{second/bottle}$$

Form the analysis of takt time shown in Table5.1 the takt time for de-palletizer and palletizer is the same which is 0.3125second/bottle, inca and deca machine also had the same result of 0.052sec/bottle, washer has 0.1625sec/bottle, filler has 0.241sec/bottle, pasteurizer has 0.205sec/bottle. And monthly takt time of the bottling line process is 0.1244sec/bottle. The bottleneck process is washing process with 0.1625 second to complete washing of one bottle.

5.1.2 Uptime (%)

Table5.2 shows Uptime for each machine in the bottling line process Up time is over all equipment efficiency and it is calculated as follow: -

$$\text{Uptime} = \frac{\text{Total time} - \text{Down time}}{\text{Total time}} * 100$$

Table 5.2: Uptime for each machine

Machines	De palletizer	deca	washer	filler	pasteurizer	labeler	inca	palletizer
Total time	856.4min	142.7 min	453.4 min	611 min	510 Min	630 min	126 min	756 min
Down time	260min	50min	0min	137.4 min	0min	91.7 min	16.3 min	229 min
Uptime%	69.69	64.68	100	77.51	100	85.45	87.09	69.69

up time of the machines were shown in Table5.2 included 69.69% of total time was uptime for both de palletizer and palletizer, inca and deca machine has 64.68% and 87.09% uptime respectively, washing machine and pasteurizer operated all the time of the process which means they had 100% uptime, filling machine has 77.51% and labeling machine has 85.45% of total operation time during the shift.

5.1.3 SIPOC Diagram

Is drawn using information collected during case study, it helps to clearly understand the input, process output, supplies of materials and to know who is the customer.

Suppliers for the bottling line are beer production team found next door to the bottling line process and stores of raw materials those supplies raw materials including empty bottles, crowns, chemicals and other machinery equipment required for the process. The second column in the diagram shows the input materials such as produced beer received and raw materials (empty bottles, crown, labels, crates, laser ink, adhesive tape, caustic soda, sulfur, nitrogen, manpower (operators) and different machine settings (speed of operation, milliliter of the filling and crown and labels position) form the supplies for the bottling process. The third column of the diagram shows the main process of the bottling line including different operations on the line such as, de palletizing empty bottles to the line, washing, filling and crowning, pasteurizing filled bottles, labeling (body and neck), bar coding (production and expired date), crating 24 filled bottles, palletizing (packing filled crates) and transporting finished products to the customer. The next column shows the output of the process which is 24 bottled beers in a crate and the customer of the process are shops, distributors and wholesalers.

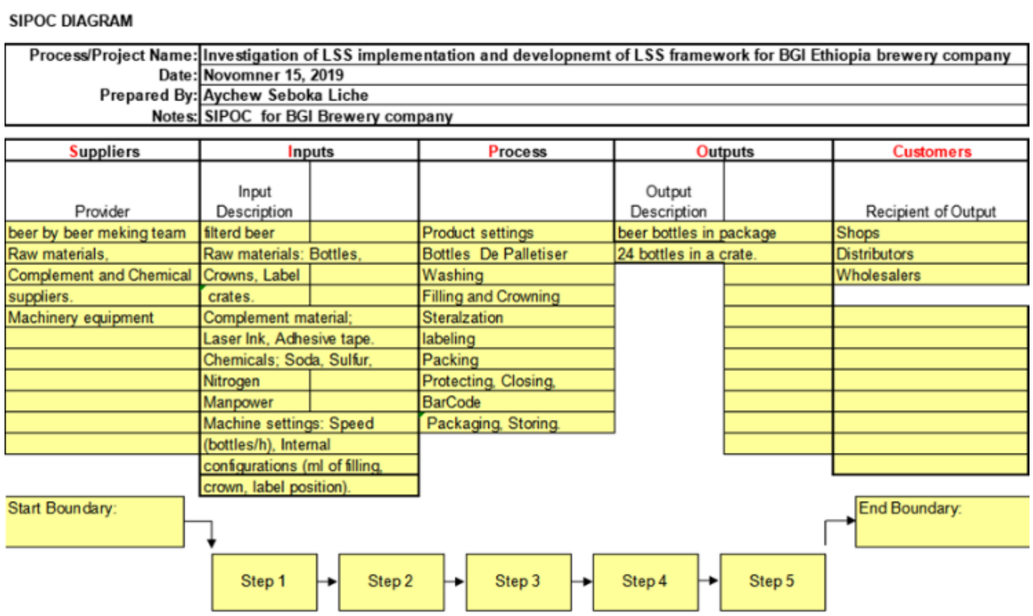


Figure 5.1: SIPOC Diagram (Author)

The diagram shown in Figure5.1 gives all information regarding suppliers for the bottling line process, input materials; types of process performed on the line, output of the process and tell who the customer of the bottling line process is. As a result, beer production team and store managers are the supplier of the line and the materials the supply are filtered beer, empty bottles, labels, crown, crates, laser ink, adhesive tape, caustic soda, nitrogen, sulfur and also inputs from the line are manpower, machine setting and configurations. The process included product setting, bottle DE palletizing, washing, filling and crowning, sterilizing, labeling, bar coding, packing and storing or transporting. The output of the line is 24 packed bottles of beers in a crate and the customer of the process are shops, distribute r and wholesalers.

5.1.4 Current Value Stream Map

After collecting speed of machine, Batch, Cycle time, analyzing of Takt time and Uptime and drawing SIPOC diagram Value Stream Map was drawn using Sigma-XL software as follow to show the current status of bottling process. This map shows all process on the line including the flow of materials such as, flow of produced beer through the process and flow of other raw materials including flow of empty bottles received and passes through (washing, filling, pasteurizing, labeling, inca-deca and palletizer machines) and flow of other chemicals and man power. The other is flow of information starting from customer feedback to the delivery of end product of the process to the customer. Including, customer feedback from sales department to monthly production planning team, information regarding daily production plan, regarding current status of machinery on the line, communication between operators and information passes between each process (process parameters feed to the process such as, speed/ bottles, cycle time, batch, takt time and up time of each machines and others).

Figure5.2 also shows eight main process of the bottling line and other auxiliary process necessary process in order to gate the required output of the process. Those process are value added and non-value-added process showed below in corrugated line.

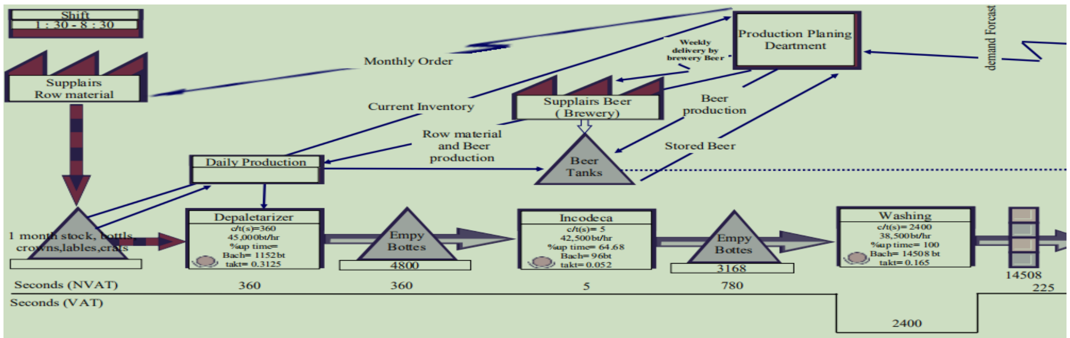


Figure 5.2: Current Value Stream Map of the bottling process

Figure5.2 showed the current state of the bottling line process. This figure gives all information about the process including; the flow information and materials on the line from different sources such as information from customer to seals department to production plan team back to the line, flow of materials between processes. Cycle time, speed of operation, batch, and value-added time were found beside takt time, uptime and none value added time shown in Table4.4, Table5.1 and Table5.2 respectively. The map also showed inventory bottles between DE palletize and deca machine, and between deca and washing machine which were 4800bottles and3168bottles respectively. The following Table shows results found from current value stream mapping.

Table 5.3: Cycle time (sec), batch (bts), speed (bt/hr) and value-added time of different machines

Machines	**Cycle time (second)**	**Batch (bottles)**	**Speed (bts/hr)**	**Value added time (second)**
De Palletizer	360	1152	45000	-
Deca	5	96	42500	-
Washing	2400	14508	38500	2400
Filling	320	13268	30000	320
Pasteurizing	2679	13028	36500	2679
Labeling	3300	12832	32000	3300
Inca	5	96	40000	-
Palletizer	198	1152	45000	-

5.1.5 Average Value of Produced Bottled Beers and Rejected and Defected Bottles

Average Produced Bottled Beers

The amount of produced beer was different in each month because of different reasons such as seasonal production like holly days which increases the productivity rates and because of scarcity of resource materials including shortage of barley (which resulted in shortage of produced beer in the tanks) or because of problems happed on the bottling line process like malfunctioning of machineries which resulted in decrease of production rates. For this reason, the average value of the year 2016/17 was taken for the analysis of the cause of defects. Figure5.3 shows the average produced beer was 12884551 bottles per month that approximated to February month production rate. the minimum production at September is very low with the production rate of 1126430 bottled beer per month which implies the demand during summer is very low because summer season in Ethiopia is cold and market movement is limited as a result during the binging of new year the company start to sell stored product. The other reason is season for harvesting barley start in October which implies there is a shortage of raw material (barley).

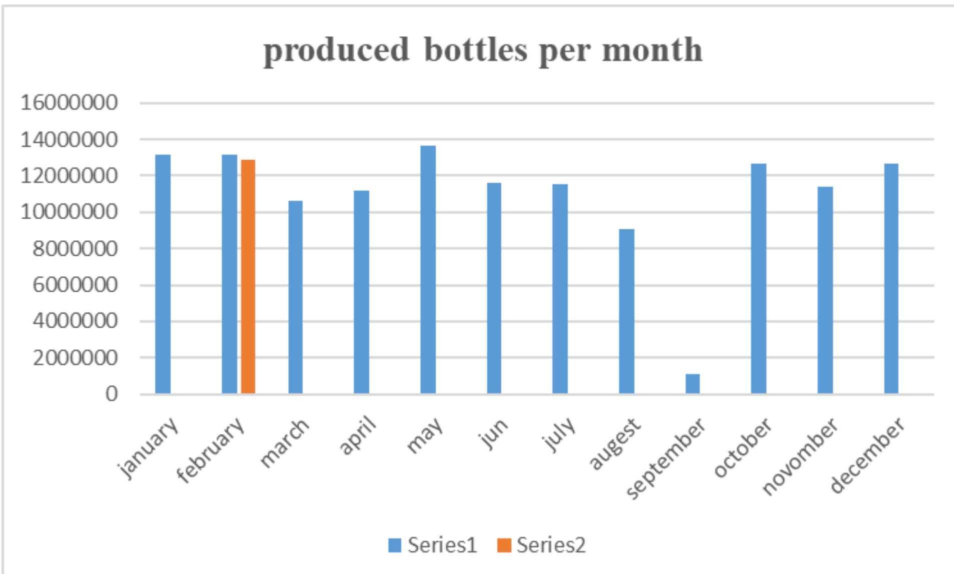


Figure 5.3: produced bottled beer per month for a year of 2016/17

Average Rejected and Defected bottles on the line

Rejected and Defected bottles were collected from one-year Daily Report of the production process during data collection; the average of data was required to analyze the current sigma level of the process. Figure5.4 shows the average values of rejected and defected bottles for a year 2016/17. As the graph shows the average value indicates 959106 bottles per month were defected and rejected from the line due different reasons explained in section 5.1.7 the average value is approximated to February monthly defected and rejected bottles. The rate of rejected and defected pottles are proportional to the rate of production as the graph shows which means the minimum rejection and defects are during September month and the maximum is during may.

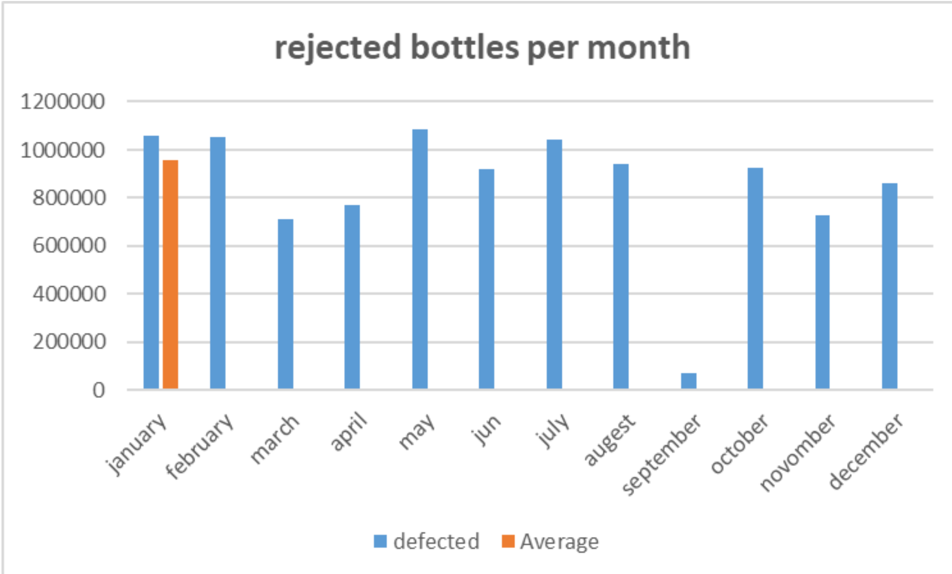


Figure 5.4: Rejected and Defected bottles per month for a year 2016/17

Figure5.3 showed the values of produced beer in a year of 2016/17 and the average value is 12884551 bottled produced beers and Figure5.4 showed the average value of 959106bottles were defected and rejected. The figure showed the average value is approximate to February month produced and defected bottles.

5.1.6 Sigma Level of Bottling Line Process

Process Sigma Level Calculator - Discrete Data		
Sample Data (user inputs):		
Number of units	n	12,884,551
Total number of defects observed	d	959,106
Number of defect opportunities per unit	o	1
Sigma Shift (typically +1.5 for long term data)		1.5
Results:		
Defects per Unit	dpu	0.07443845
Defects per Million Opportunities	dpmo	74,438.4
Defects per Opportunity	dpo%	7.44%
Yield	yield%	92.56%
Process Sigma Level	sigma	2.944

Figure 5.5: Sigma Level of the process

Sigma level of the line was analyzed using Sigma-XL software. Figure5.5 showed the level of sigma, defects per unit, DPMO, defects per opportunities, yield of the process of an average value of reject and defect. In this section the average value is used for analysis because as maintained in section5.1.5 the average value of both produced bottles and defected and defected bottles were approximated to February month production rate and rejection and defection rate. The figure shows a sigma level of 2.944 which implies the process varies 2.944 standard deviation from normal distribution and 92.56% yield means 92.65 % defect free products were produce from the total of 1000000 products and the rest 7.44% (dpo%) from the total products or 74439 bottles were defected from 1000000 products.

5.1.7 Pareto Chart Analysis

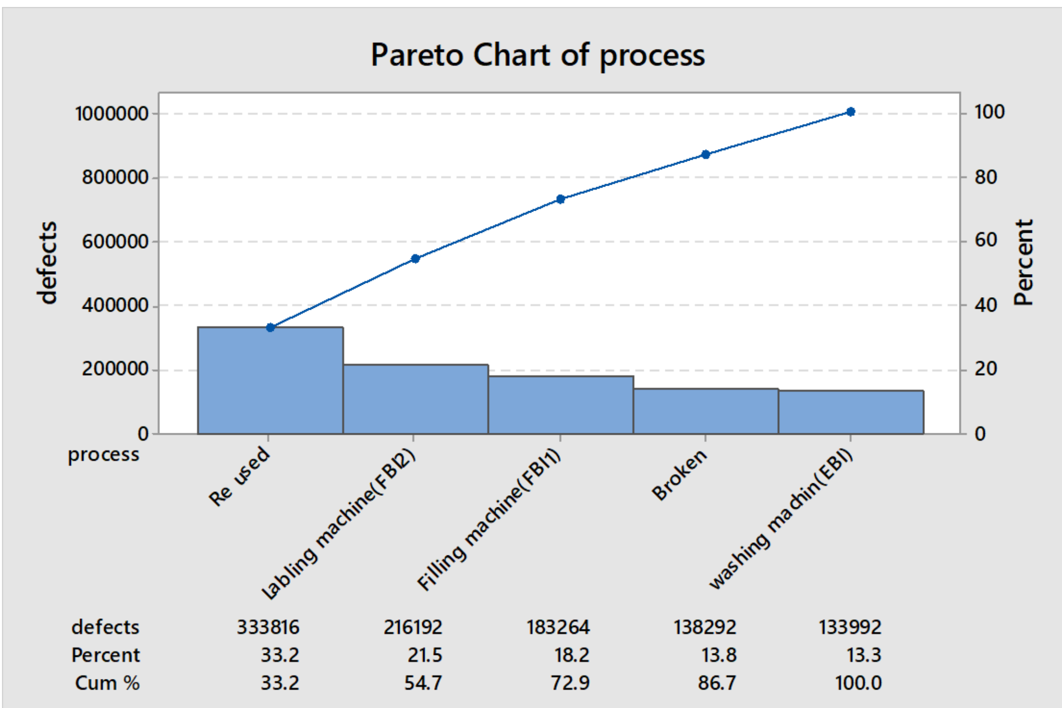


Figure 5.6: Pareto chart

The average value of rejected and defected bottles was 959106 bottles per month and these defects were because of Re-used bottles, broken bottles, under-filled bottles at Filler Machine (FBI1) and under-filled bottles after Labeler Machine and These causes of defects were prioritized through Pareto Analysis as shown in Figure5.6 drawn using Sigma-XL software.

As a result, re-used bottles and bottles rejected after labeling machine had the highest number of defects with cumulative percentage of 54.7 out of the total defects which means focusing these two defects will be the priority to reduce defects and improve the process efficiency.

5.3 Discussion

According to the Lean thinking, it is necessary to know all the processes as it is explained in the chapter 4. The bottling line processes are represented with the information collected during the case study. The value stream mapping was drawn for the St. George bottling line. Before drawing VSM SIPOC Diagram was drawn to give necessary information regarding suppliers, input materials, and type of process on the line, output of the line and customers uses the product of the line.

Suppliers were beer producing team that found next door to the line, stores of raw material. After suppliers supply produced beer, empty bottles, chemicals like caustic soda, nitrogen glue, label stamp, crown and other input materials; depolarizing of empty bottles, washing, filling of beer from tanks through line, crowning, pasteurizing of crowed bottles of beer, labeling both body and neck, bar coding, packing 24 bottled beers in crate, palletizing processes were performed. The output of the process was crated beers which were delivered to distributors, shops/ supermarkets, warehouse.

The best way to recognize the waste is through the VSM which it can be seen in Figure5.2. Using all the information the actual situation of the bottling line is represented where the main flow material are the bottles of beer. Other raw materials are necessary for the line to produce the final bottle. So, the bottles flow involves the quantity of other raw materials necessary because each bottle needs one crown, two labels (body and neck), a box every 24 bottles, so the whole stock management can be organized. As a result, the following wastes were identified.

Inventory of Empty Bottles between Processes: - this waste was happened because of the length of conveyor between processes. In order to start the next process on the line the first operation should deliver bottles to the machine therefore; the line holds lots of bottles until it reaches the next operation this resulted high number of inventories on the line.

Underutilized Workers Was also another waste found on the line and happened because most of the process on the line is automatic for this reason the operators were not used efficiently by the line.

Over Process: - As mentioned in chapter five around 333816bottles per month were re-used by the line because of water, caustic soda, other dirties, malfunctioning of labeler that passes unlabeled bottles and put back before labeler machine again.

Over Production: - As explained during case study the company did not always used just-in-time manufacturing process. Rather they produced as much as the line could this result over production and also inventory of produced beer.

Waiting Time: - As mentioned at inventory waste the next process waited the first one because of this time was wasted in between.

Unnecessary Movement: - Was another waste happened on the line because of re-used bottles and over processing; In order to re-use and over process bottles the operators move here and there.

Defects: - Around 959106 bottles per month were defected bottles on the line. These defects will discuss in detail below.

Wastes of Other Materials: - Including bottles chemicals and produced beers were wasted in different process of the line.

The first interesting value is the difference between the lead time of a bottle and the real value-added time. The value added is referred to the processes where the bottle received an activity with added value on the final product. As result, 66min from the lead time are not value-added activities.

Nowadays, BGI Brewery as it was explained before in the chapter 4, does produced beer by both wait for the customer demand and production plan of the brewery. It is represented with the push flow of material due to it is an automatic line. Starting from the beginning, the suppliers push material depending on the sales forecasts for the next month. They always keep at least 1 month of most materials to produce always and 4 months for barley. The stock is transported to the line where each process has its own stock for the day or product that is ordered to bottle. The other supplier was itself BGI, because they make the beer from the beginning to the bottle. The bottling process starts when the company sends the beer in hectoliter already made to the tanks where it was stored until the plan production requires it to finish the product in the bottle.

Between the processes there was represented the buffer where the indicated quantity was usually in the buffer. This number varies because of the different speed of each machine. As it was told in the chapter 4, there are sensors in the belts between stages, which work as a buffer too, that control when this quantity of bottles in the previous belt decrease significantly. When this fact happens due to the different speeds, the process that receives the bottles from this belt stops and waits until the belt-buffer recovers the quantity that fit in the buffer.

Thus, the line production suffers some stops and for this reason the uptime available (see table6.1) was less than 100%. Only the washing and pasteurizing machines were working all time because the configuration of the day of the visit was that, and it was the bottleneck with the minimum speed (38,500b/h and 36500b/h) and the highest Takt production time (0.165s/bottle and 0.206s/bottle) respectively.

After the bottling line, the packaged bottles arrived to the warehouse, where they were stored waiting for the customer order. Then, the customer starts the sales process. When the order was sent to BGI, the Brewery controls the stock to send out the order to the inventory and prepare the shipping.

The Pareto diagram is one of the best tools to display this kind of information. The tool used construct and prioritize the defects and rejected bottles that occur more frequently.

The table with the defect's information was in the section 5.6 where it can be compared the percentages and the main defects of monthly production. However, the absolute number cannot be compared directly because the quantity of time and bottles were not the same. To sum up, table5.4 included the following information to compare the data and take decisions.

The line rejected an average of 959106 bottles per month from different processes of the line. From the table5.4 total 7.44 percent of bottles were rejected during 578 hours of operation it means 1 bottle rejected every 0.50 second, this indicates the frequency of rejection is very high.

About the line, the problem is focused on the washing, Filling, labeling, re-used and broken bottles (which broken in different area of the process including at EBI, crowning, in side washing machine and pasteurizer) compare to the other defects but all defects were critical considering the number of bottle rejected so, as it can be seen in the Figure5.6, re-used bottles and under filled bottles at labeling (FBI 2) were the most rejected bottles.

In this thesis what one could understand is that on the line defects that the brewery has to pay attention to reduce the over processing are three processes that generate more rejected bottles which are washing, labeling and filling.

The defects that show more difference are the re-used and under fill at labeling process. It appears a reduction the second day more than 54.7% the number of rejected bottles (%bottles). So, an interesting point to study was this defect reduction and thinking on the input parameters of the process, proper maintenance of the machines to perform well.

The current level of sigma was 2.944 and DPMO was 74439 bottles as observed from the Figure5.5 which means 74439 bottles were defected out of one million bottles on the bottling line.

Applying the calculation for the takt time in a normal month during middle of the year, for example February, the information from the case study informs about the use of 80.30% of the time on line. So, if a month has 25 available days of work, the 80.30% of the days for production line are 20:01 days. It is also considered 22:30 hours of available time, eliminating cleaning time, setup time and other planning down times. The product per day would be 643906 bottles/day, 12884551bottles/month.

This takt time is a number easy to produce for the company due to the real data was producing less than 0.1234s/bottle. The bottleneck process was the washing machine with a unit every 0.165second and pasteurizing with a unit every 0.205 second, so, this ‘extra time’ between the takt time and bottleneck process allows the company to sequence the production to reduce the quantity of stock.

Based on the production of 28874bottles/h, the bottling of 643906 bottles and including the new lead time of the first bottle until the line is working stable takes 20:30hr. The available time is 22:30hr, and then it leaves more than 1hr for the production sequence. The setup is 1hour, and time of the run-up including when the first bottles come into the processes and fill the reduced buffers are inside the time of the changeover; and having around 30min for solving unexpected problems.

In this bottling line, it can be seen some of the time wasted in the buffer, and in the inventory of bottles during bottling. The result was that 72.30% value added time, and the other time were not generating value. However, not all the non-value-added time could be eliminated with lean techniques. For instance, the De palletizer and palletizer were not included in this value-added time because the activity does not give anything for the product but it was a process that cannot be excluded. The bottles arrive from the warehouse in pallets of 3456 bottles and in each cycle time 1152 bottles were introduced into the line. So, it was an avoidable activity. All the other processes were considered part of the product because without them the process was not the same, so, they contribute to increase the value of the product.

During case study some critical success factors were mentioned including communication between departments is open and both formal and in formal and between top managements and operators is open and informal. And also, the company has interest in the opinion of the employees and they collect information and suggestion every day from the production plant. So, the employees are somehow involved and encouraged with the company and they would be ready if the managers wanted to develop a lean production.

The other issue mentioned was manufacturing challenges including benefit such as increase customer satisfaction, reduction of costs and reduction of cycle time; limitation factors such as bureaucracy and shortage of green currency/dollar, which the researcher is going to include during conceptual lean six sigma framework development in the next chapter.

5.4 Summery of Chapter

In this summery, the data were collected, analyzed and the results were discussed respectively. Both qualitative and quantitative data were collected from bottling line including data through interview of different employees of the company, observation of bottling process, measurements of different operational parameters as explained in the case study and from previous recorded data of the bottling line process after that the data regarding the takt time of the process, uptime (OEE) of the machines, the process flow of the bottling line (VSM), average defected and rejected bottles on the line, Pareto analysis for prioritizing defects were analyzed accordingly. Then results were discussed at the last section of this chapter.

Chapter Six

Conceptual Lean Six-Sigma Framework Development

6.1 Introduction

LSS framework is systematic blueprint used to improve process completion idle time, reduce defects in the process and eliminate wastes that cause reduction productivity. In this study a conceptual framework is developed based on the results found from literature review and case study including wastes and defects found on the bottling line, critical success factors and impeding factors found from both literature review and case sturdy as shown in chapter five. The framework development is also based on DMAIC approach which is the baseline in the implementation of LSS manufacturing methodology.

6.2 Critical Success Factors and Impeding Factors

The critical success factors are the key managerial and technical factors in which the company must be well recognized in order to guarantee the success of the process and obtain high performance (Saja et al., 2016). Impeding factors are challenges which affect the success of the organization during implementation of LSS manufacturing methodology. As maintained in section 6.1 from literature review and case study the following critical success factors and impeding factors are considered in developing the framework.

6.2.1 Critical Success Factors for LSS Implementation

Piotr W. (2014), Timans et al., (2012) review and agreed on the following critical success factors: - Organizational structure change, Education and Training, Management initiative, Communication, Employee's involvement, Employees Motivation, and the researcher added some critical success factors from company context such as Financial capability of the organization, Linking LSS to customer, Linking LSS to other department working bureaucracy of the company.

Organizational culture

Cultural change is the basic success factor for the organization to succeed on the implementation of LSS manufacturing methodology. Leadership play a vital role on cultural change the organization because leadership can be considered as a source of beliefs and value that has the ability to convince, motivate and get them to cooperate in order to achieve the organization goal. Implementing organization cultural change in BGI Ethiopia Brewery Company will be very challenging because there are many barriers regarding organizational change including fear of losing customers and financial crisis among stockholders, fear of economic, social and environmental change among employee of the organization, fear losing the position among low and middle level managements leads them to resist for change. In order to succeed top management must be first in line to start and initiate the change.

Management initiatives

As said before the managements are first in line for change which is very important because convincing employee of the organization will be much easier for the managements. In addition, they know all the organization structural and the performance of each employee including strength and weakness of the employees for these reason management's initiatives is very important critical success factor to implement developed conceptual framework for BGI Brewery Company St. George bottling line process. A management initiative helps employees to understand the clear picture, objectives and goals of implementation which will motivate employee to involve in implementation process.

Education and Training

Education and Training is another critical success factor to implement LSS Framework on the bottling line process. As discussed in case study of this thesis most employees to BGI Brewery Company on the line were lower level graduates and some of them were uneducated and very few of them were higher educational graduates this will affect the implementation process unless education and training regarding LSS manufacturing process and LSS Framework implementation is given to the employees.

Communication

Communication is the other critical success factor considered in development of LSS Conceptual Framework. Communication among the functional group will make the implementation smooth. As seen in case study of this thesis employee of the company on the bottling line is communicated with other section of the company and with each other in current manufacturing situation which is good thing because it will not difficult to communicate during implementation of the Framework.

Employee Involvement

Employees are the primary customer of the company and also, they involve directly in the production process than managements, they know the nature of production line and nature of problems happened on the line. For this reason, involving the employee in implementation of developed conceptual LSS Framework is considered as a critical success factor.

Employee Motivation

One of impeding factor for successful implementation of LSS manufacturing methodology is time consuming which will result in exhaustion among employee. In order to resolve this problem motivation of employee is very important and critical. Motivation includes moral supports and financial rewards like bonus and give chance to upgrade their educational level for the employee included in functional group which results motivating both functional group and other employees of the company.

Financial Capability of the Organization

Lack of finance is the other impeding factor in current manufacturing process of BGI Company which affected the production quality of the bottling line process. For this reason, financial capability of the company is considered as a critical success factor in the Development of Conceptual LSS Framework. Finance is the basic aspect for implementation for different tasks like education and training require funding, recourse like software, and fee and bounces for expertise and functional groups involved in the process and other costs.

Linking to the Customer

LSS must integrate with its customer because customer is the end product user of the process and in order to know the quality of the process and product the customer must understand what is going on the process. In addition, customer is the one source of feedback for the process regarding the product the bottling line process produced which means; the customer will be the critical sources of input to improve the product and process quality and also will help to sustain the improvement process through continuous feedback.

Linking LSS to Company Bureaucracy

Bureaucracy in BGI Brewery was very long and exhausting that resulted in decrease productivity of the bottling line process at current state by wasting time and finance which could be used for process improvement. To implement Developed Conceptual LSS Framework on the bottling line company bureaucracy must be linked with LSS.

6.2.2 Impeding Factors of LSS Implementation

Saja et al., (2015) argued and prioritize the following impeding factors for successful implementation LSS manufacturing methodology: - Time consuming, Lack of resource, unmanaged expectation, Lack of awareness about LSS Manufacturing Methodology and Lack of training or coaching.

Time Consuming

Implementation of developed conceptual framework will requires lots of time including time for education and training, time for implementation (form Phase1- Phase5) which will create fear among stakeholders and top managements, fatigue among employees (functional groups) and will challenge the patient of other employees in the organization.

Lack of Resource

Lack of resource is another impeding factor which will affect the implementation process. Source including funding, availability of appropriate software and others

Unmanaged Expectation

Improvement in LSS manufacturing implementation is gradual for this reason the organization and the employee should manage their expectation. Because, as explained implementation of LSS is very difficult and should be carefully and step by step.

Lack of Awareness about LSS Manufacturing Methodology

In BGI company where the study conducted only one person has heard about LSS manufacturing methodology. Which means lack of awareness regarding LSS manufacturing methodology and its implementation process is visible impeding factor.

Lack of Training or Coaching

Training is not one-time activity in LSS manufacturing process because continuous improvement requires continuous training and practice. Lack of training and coaching will affect this continuous activity and will results in failure on implementation.

Table 6.1: summery of critical success and impeding factors for LSS implementation

Critical success factors	**Impeding factors**
Organizational culture	Time consuming
Management initiatives	Lack of resource
Education and training	Unmanaged expectation
communication	Lack of awareness about LSS manufacturing methodology
Employee involvement and motivation	Lack of training and coaching
Financial capability of the organization	
Linking to the customer	
Linking LSS to company bureaucracy	

6.3 Component of LSS Conceptual Framework

There are two components in the development conceptual framework for this study as shown in figure6.1. These components are Strategic elements; which are the main drivers required for successful implementation of LSS manufacturing methodology and Operation elements; including the key factors for successful implementation of the operation system and obtaining high quality performance and DMAIC approach is integrated with each other during development of the framework. Generally, elements of the framework include a set of quality tools and statistical tools to formulate the stages of the framework

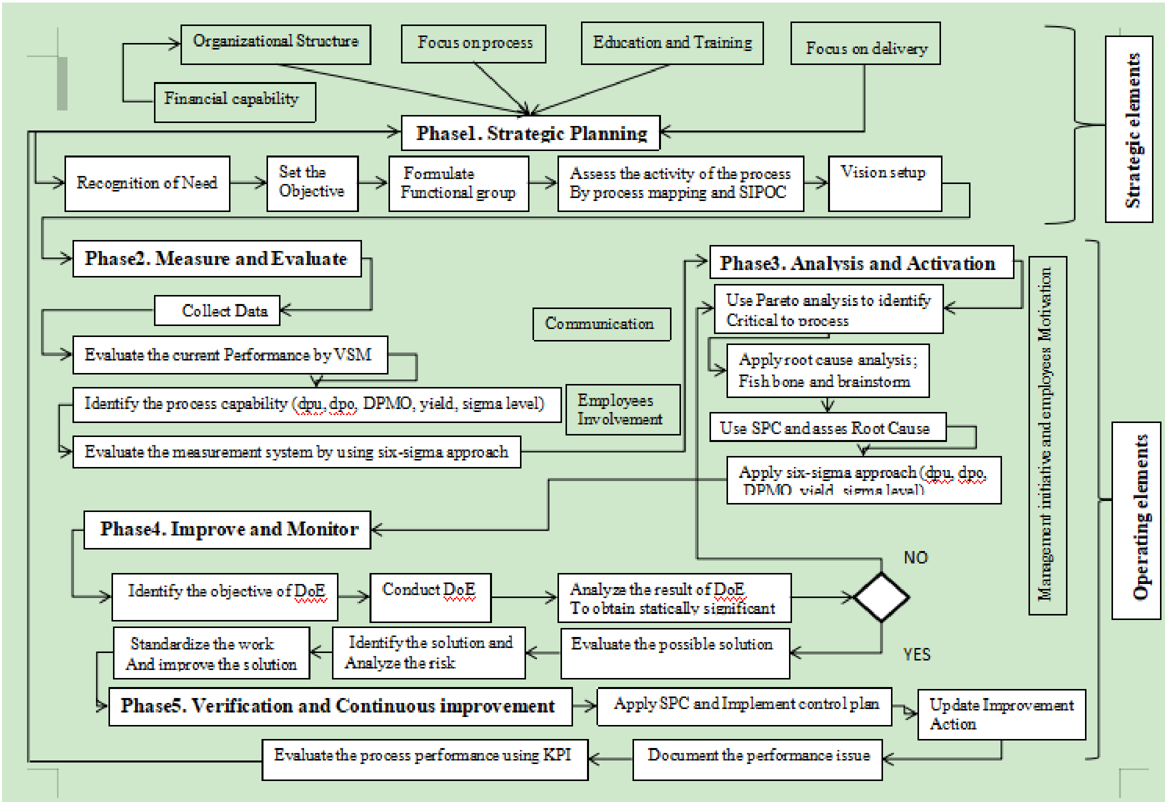


Figure 6.1: Conceptual Lean Six-Sigma Framework for St. George Bottling Line Process

6.4 Implementation Steps for LSS Framework on Bottling Line Process

The implementation procedures for the framework are summarized in five sub process as follows:

Phase_1. Strategic Planning

In this phase the framework the strategic tools for organizing and planning the implementation process is used. The procedure includes (1) Recognition of needs (specify what resources are needed for the implementation including time, human and other resource materials for the implementation of LSS framework on the bottling line process.), (2) set the objective (what the company will achieve after implementation of the framework on the bottling line.), (3) formulate functional group (form the functional team that will conduct the implantation process. This team includes employees from all level of bottling line process and also members of top management.), (4) asses the activity of bottling line process through process mapping and SIPOC Diagram, (5) set the vision (the bottling line vision must be defined without contradicting the strategy of the company).

Phase_2. Measure and Evaluation

This phase enhances and prepare the bottling line process in order to improve the process and includes the following steps; (1) evaluate the current status of the bottling line process through VSM, (2) identify the process capability of the line by dpu, dpo, DPMO, yield and sigma level, (3) evaluate the process performance system using six-sigma approach.

Phase_3. Analysis and Activation

The purpose of this phase is to analyses the possible cause of the problems in the line and includes the following steps; (1) Pareto analysis is conductor in order to prioritize defects found on the line, (2) analysis of root cause through fish-bone diagram in order to identify the critical cause of the problem, (3) use statistical process control tool in order to assess the potential cause to detect variation on the process of bottling line, (4) apply six-sigma approach(dpu, dpu, DPMO, yield, sigma level) and future VSM to identify the gap between the current and the targeted performance.

Phase_4. Improve and Monitor

The aim of this phase is to identify the possible solution of the problem and improve the bottling line process and includes the following steps; (1) identify the objective of DOE, (2) conduct DOE to improve the root cause of the problem(3) analyze the result of DOE to obtain statistical significant(if it is not significant go back to analysis and activation phase and start over to identify the right problem and cause of problem) if it is significant, (4) evaluate the possible improvement solution, (5) identify the solution and analyze the possible risk during applying the solution, (6) once the solution is evaluated and selected standardize the work and improve the solution.

Phase_5. Verification and Continuous Improvement

The purpose of this phase is to sustain the improvement action taken and to continuously improve the improvement action itself and includes the following step; (1) apply statistical process control tools and improvement control plan in order to sustain the improvement, (2) update the improvement action in order to get continuous change on the bottling line process, (3) document the performance issue which will used as a reference for the next improvement process on the line and also for other related implementation process, (4) evaluate the performance of the process using key performance indicators to sustain the improvement action.

6.5 Summery of Chapter

In this chapter, the conceptual framework was developed for the bottling line process of BGI Ethiopia Brewery Company. This framework has two elements namely strategic elements those were the main drive for successful of the framework and operational elements which included key success factors for development of the framework. These two elements were integrated to each other and used DMAIC approach as base line. Critical success factors and impeding factors were used from literature review and some were added by the researcher. Critical Success Factors such as Organizational Culture, Management Initiatives, Education and Training, Communication, Employee Involvement, Employee Motivation, Financial Capability of the Organization, Linking LSS to the Customer and Linking LSS to Company Bureaucracy were explained in order to understand them before including to the implementation of Conceptual LSS Framework. In addition, the Impeding Factors like Time consuming, Lack of resource, Unmanaged Expectation, Lack of awareness about LSS Manufacturing Methodology and Lack of Training or coaching those will affect the success of Conceptual LSS Framework Implementation. This conceptual framework has five phases of implementation (Phase1 Strategic Planning, Phase2 Measurement and Evaluation, Phase3 Analysis and Activation, Phase4 Improve and Monitor, Phase5 and Verification and Continuous Improvement). Structured questionnaire will develop after implementation of the framework in order to investigate the sustainability of the implementation.

Chapter seven

Conclusion and Recommendation

7.1 Conclusion

Lean six-sigma is a combination of two powerful methods: lean and six-sigma, combining these two methods gives improvement team a comprehensive tool-set to increase process capability. Lean manufacturing focus on elimination of wastes and six-sigma focus on reduction of defects and variation. Therefore, integration of these two powerful manufacturing methodologies is wise move for manufacturing industries. After case study conducted on BGI Brewery Company and literature's related to lean, six-sigma and lean six-sigma reviewed the thesis focused on development of conceptual lean six-sigma framework for bottling line process. This thesis identified the current states of BGI bottling line process including the process flow, Wastes, defects found on the line.

From literature so far, number of literatures related to food processing industry is very few. there is no one article published related to beverage industry in Africa. In this regard, a new type of model is developed that filled these gaps in the literature.

Observation was made over 10 times while measurement was conducted over 30 times. And 13 interview responses were gathered. The response rate for proposed data source was indicated that interview resulted 50% of response among the respondents; observation resulted 83.4% of respondents and measurement resulted 100% of respondents.

The following results were found from case study and data analysis

The takt time for the bottling process is 0.1234sec/bottle which means every 0.1234 second one bottled beer is produced and the bottleneck processes are washing and pasteurizing operation with takt time of 0.165s/bottle and 0.206s/bottle respectively.

Inventory, over process, over production, waiting time, unutilized worker, waste of resource materials and unnecessary movement are wastes found on the line.

Average produced beer per month is 12884551 and defected and rejected bottles are 959106 bottles which is approximate to February month production and rejection rate of a year 2016/17. And the sigma level of the process is 2.944 with 74439 defected bottles per million.

Pareto chart shows re-used and under filled at labeling machine cover 54.7% of defects. Current value stream map shows72.3% is value added time and 66 minutes is none value added time.

Generally, the above results showed the current status of the bottling line clearly which was led to the development of conceptual lean six-sigma framework. The framework was developed for St. George beer bottling line and beside; lean tools and six sigma tools critical success factors and challenges for successful implementation those found during case study from the company were considered.

7.2 Recommendation

Lean, six-sigma and the integration of both methodologies are very powerful and effective methodologies. Therefore, implementing these methodologies is very advisable for different organization.

- Most Ethiopian manufacturing industries are using conventional manufacturing process; to improve their manufacturing capacity and to be competent in world market Ethiopian manufacturing organization must consider implementing lean six-sigma manufacturing methodology.
- To successfully implement proposed framework, the company must be committed for the methodology and must do whatever needed to be done in order to achieve the objective and goal of the methodology.
- As mentioned during literature review number of articles published on LSS implementation on food processing industries was very few. For this reason, the researchers must think about the gap showed in this thesis and act on it.

7.3 Future Works

The following point will be an idea for the future work

- Implementation of developed framework on the bottling line process of BGI brewery industry.
- Investigate the sustainability of proposed LSS Conceptual Framework for BGI bottling line process.
- Development and implementation of LSS framework for beer production process of BGI brewery industry.
- Development and implementation of LSS framework for sales department of BGI Brewery industry.

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Appendix

Appendix1

General information about the methodology

1. Does the brewery implement Lean manufacturing or Six-sigma procedures?

a. Lean b. Six-sigma c, both **d, none** e, other

1.1. Do the mangers have notions about Lean or Six-sigma? **a. Yes (one)** b. No

1.2. Do the operators have notions about Lean or Six-sigma? a. Yes **b. No**

2. Does the brewery use some continual improvement techniques? a. Yes **b. No**

2.1. Which one? In the growing and beer making, taking samples and analyzing attributes values. Both

3. Does the brewery have some waste reduction plan in the processes? a. Yes **b. No**

3.1 In which areas or processes?

4. Which of these wastes do you consider there are in the brewery? Sort them.

a. Overproduction (1) b. Waiting (1) c. Transportation routes **d. Over processing (1)**

e. Inventory (1) f. Operators Movement (2) g. Defects (1) h. Underutilized people (2)

k. waste of resource materials (1)

5. Does the brewery implement defect reduction strategy? a. Yes b. **No** Which one?

6. Does the brewery implement variability reduction strategy? a. Yes b. **No** Which one?

7. Has the brewery implemented some quality projects in the past? a. Yes b. **No.**

8. What is approximately the demand (bottles) from all products per year? **They do not know**

9. Who are the customers**? a. Shops b. Supermarkets c. Distributors d. Wholesaler**

10. How is this demand curve? a. Regular b. Random **c. Seasonal** d. Unknown e. Other

10.1. How is the predictable demand from each client? **Up and down**

11. What is the batch size of bottles? **Depend on demand**

12. How many kilos of barley received every year? **840,000kg/year**

13. What percentage is profitable of the barley received? **100%**

14. Is this production adjusted to the forecast demand? a. Yes b. **No**

15. What does the brewery do if the beer produced is more than the required for the demand? **They bottled Produce beer anyway**

16. What is the quantity of barley they received in once time from the supplier? **High**

17. How many months is the beer bottling? **a. The whole year** b. Some months: c. Days:

Communication, Involvement and skills employee's

18. How is the communication? A. From top to down B. Some department's two-way communication **c, Open, two-way with feedback** d, other: ___________

19. Is there a method to collect suggestion from the employees? a. Yes **b. No**

20. Does the employee suggest improvements for its workplace and job? a. Yes **b. No**

21. Do the employees know about the managerial objectives of the company? a. Yes b. No

22. Do employees of the operation line know about the number of bottles needed to produce? **a. Yes** b. No

22.1 Do they know about the takt time? a. Yes **b. No**

23. Are the employees encouraged with the objectives of the brewery? a. Yes **b. No**

24. Do they know about improvement strategies of the process? a. Yes **b. No**

25. Do you consider the employees are ready for a change in the working way? **a. Yes** b. No

26. is there communication and exchange of information between shifts? **a. Yes** b. No

27. Do the employees know about the preventive maintenance of their equipment's? **a. Yes** b. No

28. Who is the responsible of the maintenance of the machinery? **a. Employee user** b. Maintenance people c, a maintenance service company d, other: __________

Judoka, devices, standardization

29. Do the operation line employees have the skills to fix a problem in the operation line at the same moment? **a. Yes (partially)** b. No

30. Do the equipment have some devices to detect when the bottle is in the process or when is not? Example: To not fill a place without bottle. **a. Yes (partially)** b. No

31. Do the bottling line machines have devices to detect abnormities during the same process? **a. Yes** b. No

31.1. Do these abnormalities arrive to the end of the line? **a. Yes** b. No

32. Do the employees have the power to be able to stop the whole bottling line process? Example: Because it is putting the labels wrong, or it is filling less quantity. **a. Yes** b. No

33. Is there a line stop system in the bottling line? **a. Yes** b. No

34. Who has the responsibility for problem solving? a. shift coordinator b. Teams Manager c. Small employee teams **d. All employees are asked** e. Others: ___

35. Can the operators usually solve the problem, detect and refuse bottles when they realize about a bad bottle? **a. Yes** b. No

36. Are the maintenance processes standardized**? a. Yes (for some)** b. No

37. Are the operator's activities standardized to not create differences in times, quality or efficiency between shifts and people? a. Yes **b. No**

38. Are there visual devices implemented? **a. Displays in the machines configuration (Andon) b. Boards of visual promotion of information (training, safety, quality …)** c. Others: ________

Voice of the Customer VOC, CTQ's

39. Does the brewery received feedback from the customers? **a. Yes** b. No

39.1. What is the way? **a. Telephonic b. personally c. Complaints department**. d. Others: e-mail

40. I have seen on mass media some award-recognition of the products. Does the product have some attributes that the customer does not valuate or spending much time and cost for the award recognition? a. Yes **b. No**

40.1. Are the sales related with the number of awards of the products? **a. Yes** b. No **Maybe the customer is looking for another flavor different than the committee of the beer competitions.**

41. Are these attributes that the customer appreciates more? Sort them **a. Visual (Design Bottle, label, packing) b. Smell c. Color d. Taste e. cost** f. Others: **_____**

42. What is the opinion about the products from the customers? **High quality/price**

43. What is the customer opinion about the reliability of the products? From 1 to 10 (top):**9**

44. What is the customer satisfaction? a. < 80% **b. 80-90%** c. 91-95% d. 96-100%

45. Could you sort these purchase factors based on importance?

a, Delivery on time (1) b. % of the order completed (1) c. Price (1) d. Time of especial deliveries (2) e. Relationship (3) f. Development of new product (3) g. Brand image (2) h. Products discounts (4) i. Proximity with the client (4) j. Others: **_______**

46. Are there some factors to measure the last factors? a. **Yes** b. No Which one? Sales reports

Bottling Process

47. How is the bottling line processes? **Product/ shift**:

48. Is there a continuous flow inside the bottling? **a. Yes** b. No

49. is there continuous flow with the input and output (after the previous stage, with the distributor or client)? **a. Yes** b. No

50. Is filtering done just before comes into the bottling line**? a. There is a previous storage stage** b. It is the filtering include in the bottling line process. c. It is between the tanks and the bottling process

51. What is the bottleneck in the process? **a. Washing** b. filling c. crowning d. Labeling

e. crating **f. Pasteurizing**

52. Does the bottling line have “buffers” inside the production line? **a. Yes** b. No

53. Does the brewery implement SPC for controlling the processes? **a. Yes** b. No Where?

Beer-making stage and in some steps of the bottling line, they control if the variables are inside the specification limits without a SPC. After the bottling, they control a sample everything in the laboratory with the same methodology.

56. What is the information that they keep in the Bottling process? a. Values of variables b. Efficiency, performance, machinery **c. Number of defects from each one** d. Takt time Palletizer Protecting, Closing, Barcode Packing, Labeling, Washing Filling, Crating Packing 25 boxes e. **Speed machinery** f. Bottleneck process g. Other: __________

57. Does the company register time about the bottling process? a. Cycle times b. **Changeover time's** c. **Operator's times d. Breakdowns times'** e. Takt time f. Others:

58. Do they take samples to control the final quality of the products? **a. Yes** b. No

59. Do they take samples to control of the intermediate quality of the products? **a. Yes** b. No **(sterility of empty bottles)**

60. How is the samples time procedure? a**. Always at the same time** b. Every specific time c, Random time d, other _______________

61. after bottling line**? One bottle per hour at the end of the washing at the end of labeling machine each**

62. Are the inspections carried out at the source of the problem? **a. Yes** b. No

Defects, Six-sigma, Stock, Materials

63. What are the common defects/mistakes in the bottling production line? **a. Broken bottles b. Quantity of liquid filled d. Bad cleaning of the bottles f. Operator's mistakes**

g. operators reprocess the bottle.

64. Does the company use the Pareto chart defects? a. Yes **b. No**

65. Do you compare and take advantage from past data? **a. Yes** b. No

66. What kind of comparison is useful for them? a. Benefits b. Performance machinery c. Performance's operator **d. Number of rejected bottles/lots e. Quantity of defects** f. Others: __

67. Are they planning improvements in the beer-making? a. Yes **b. No**

68. Do they have stock of bottles, crowns, input materials? **a. Yes** b. No

69. How is the replacement of these materials? a. Always the same quantity b. Depending on the necessary units (from the production plan based on forecast) c. When there is no material **d, when the operator considers it necessary** e. Other: _________

70. Are the raw materials delivered directly at the point of use? **a. Yes** b. No Suppliers

71. How many materials are suppliers of the brewery for the bottling process of raw material? a. Crown b. Bottles c. Crates d. Chemicals (sulfur, nitrogen) e. Adhesive tapes f. Boxes **g. All**

72. How is the brewery demand to these suppliers? a. By security stock point b. **Every time (month**, 60 days, other) c. Other: ________

73. When does the company decide to bottle the beer? a, under customer's order b, Predictable demand c, when the beer is ready to bottle **d. all**

74. Do they produce stock of beer in tanks or other place before send to the bottling? **a. Yes b.** No

Stock of Final product, JIT and OEE

75. Is the brewery producing the beer and moving to the last bottling when they receive the order? **a. Yes** b. No

76. Does this beer stored in tanks have a maximum time to be there? **a. Yes** b. No What time? **One month**

77. Is the production of a finished bottle stored in the brewery waiting for the customer's order? a. Yes b. No

78. Does the final bottle deteriorate the quality if it is stored? **a. Yes** b. No

78.1. How much time is a maximum for the storage? **a. 1 Year** b. Other: More than one year, a lot of time.

79. Do they sell under FIFO order? **a. Yes** b. No

80. How much time is the equipment actually used? **Six day a week (24 hours)**

81. What are the parameters to calculate the output performance? **a. Bottles/h** b. OEE c. Other: __

82. What is the OEE of the bottling line machines? a.<65% b. 66-75% c. 76%-85% d. >85% e. Other: They do not work under efficiency parameters. **They do not know**

83. Where are the most common breakdowns in the bottling line? a. Washing **b. Filling** c. Crowning **d. Labeling** e. Crating f. Other:

84. What are the causes of the breakdowns? a. Operator do not follow the manual operations b. **Improper maintenance** c. Electrical connections d. Overrunning machine's capability e. Problems between belt and machine alignment f. Ignoring warning signal g. Untrained workers (not all) h. **Others: quality of glue and operator problem during mixing glue**

85. And the causes for stoppages? **When there are problems on the line and machines**

86. Is the machinery working at the designed speed? a. Yes **b. No, lower (buffer inventory)** c. No, higher d, other:

5S, VSM, Changeovers, Standardization

87. Do the employees or company review unnecessary items or potentially removal items? Sort **a, Yes** b. No

88. Do the tools have a designed localization? **a. Yes** b. No

98. Do the same workers clean their workstations as a routine and continuously? a. Yes b. **No, cleaning service** c. No, not regularly d. Other

90. Are in all procedures habitual the continuous 3S first? a. Yes **b. No** c. No

91. Are the processes standardized and reviewed? a. Yes b. No c**. Not reviewed often**

92. What is the lead time in the bottling line? **they do not know about it**

93. What are the cycle times of the machines? (If it is possible to take data) **They do not check times.**

94. What is the number of operators in the bottling line in one shift? **9**

95. How many shifts are during a day? **3**

95.1. How many hours the shifts? **8 hours**

96. How much number of different beers are they bottling in the bottling line? **2 types**

97. Is the bottling line process sequencing the different types of beer in the production plan when they have different beers ready to bottle? a. Yes **b. No**

98. Are the movements of the employees optimized? (Reducing Movement waste) a. Yes **b. No**

99. Does the operator have a performance schedule for the repeatedly activities? a. Yes **b. No**

100. Is the brewery standardizing the procedures of the employees in the bottling line to reduce waste of time? a. Yes **b. No**

101. Can the employees work in other job place to replace the absent of someone? a. Yes b. No **c. Some of them**

102. Do they use universal tooling and systems for faster changeover? a. Main areas have standard tooling b. All areas have standard tooling and systems are standard **c. No**

103. Are the bottling line structures as a manufacturing cell? a. Yes **b. No**

Appendix 2

BGI ETHIOPIA	PROCESS OF PACKAGING	Revision:00 Date:26/10/2015
BGI Ethiopia	DAILY BOTTLING PRODUCTION REPORT	
ST.GEORGE	Starting date of application:26/10/2015	Reference:STGF-PC07-PG01-RE24

Date: 2/Dec/17

	Filler						
				HL in BBT	0.00	Bottles Produced	436992.00
Start	23.00	Product	St.George	HL Received	1494.00	Cases Produced	18208.00
Stop	20.50	Filler speed	35000	Empty bottles received	472320.00	HL Produced	1442.07
Paid Hrs	21.50	Actual avarage speed	35000	Theoretical B/Day	752500	Product loss	3.48
		J				Line efficency	68.61
Damaged crate replaced		0.00	Crts			Machine efficiency	84.27

REJECT				
EMPTY		Full		
Cause	Bottles	Cause	Bottles	
Appo	1056.0	Uncrowen		
Re.usable in SG.	16104.0	Under filled(FBI 1)	4416.00	
For disposal		Under filled(FBI 2)	7536.00	
Return to Komb.	192.0	Laboratory 1	0.00	
Damaged crate	0.00	Laboratory 2	0.00	
		Others	0.00	Loss due to under filled btls
Total	17352.00	Total	11952.00	2.64%

BREAKAGE			
EMPTY		FULL	
Cause	Bottles	Cause	Bottles
Depalletizer		Filler	
Case washer		Palletizer	
Washer		Crater	
EBI		Con/Pasto	
Total	0.00	Total	6024.00
		Breakage Loss %	1.28
Glue used in gm/hl		0.00	

DOWN TIME				
	Time			
Causes	From	To	Total	Description
Pal/Depal			0.00	0
Crate washer			0.27	0
Washer			1.15	0
EBI			0.82	0
Filler			2.92	0
FBI 1(Bottle Zone)			0.00	0
Pasteurizer			0.07	0
Labeler			0.57	0
FBI 2(crate Zone)			0.00	0
Crater			0.00	0
Electric black out			0.00	0
Others			0.90	0
		Total	6.68	

Returned to Empty Store		
	Bottles	
APPO		
BRIMER	29304.00	1221
FOREIGN		
Empty Crates	XXXXXXXX	251.00
Total	29304.00	1472
Balance with FGS	0	0
Bottle Counter	Decrater	16,528
	Washer	333,304
	EBI	450,253
	Filler	450,182
	FBI 1	445,332
	Labler	444,538
	FBI 2	435,420
	Crater	18,280

Appendix 3

month	produc	production spee	hl recive	empty bottle recive	theortical B	bottle produce	rejecte	ottles		breaka	downtim	returen to stor	paid ho
							empty	full	empt	full			
january	st.george	35000	44867	14238720	21806400	13127456	562668	353976		140380	149.9	917868	623.04
february	st.george	35000	44973	14192640	20228250	13137688	472224	444456		138272	142.0833	916680	577.95
march	st.george	35000	36065	11369088	16415000	10631288	386088	212136		112216	97.05	625584	469
april	st.george	35000	38037	11980800	18373950	11211053	425688	222408		121651	119.25	648096	524.97
may	st.george	35000	46277	14726016	22379350	13638184	662424	255312		170096	167.6833	917736	639.41
jun	st.george	35000	39394	12516480	19819450	11588904	474192	273768		171480	161.5167	756096	566.27
july	st.george	35000	39610	12651264	21046550	11543924	530712	379848		129484	182.0667	977856	601.33
augest	st.george	35000	31274	10012032	15593900	9042776	512856	324840		103912	127.4833	865344	445.54
september	st.george	35000	3795	1195776	1983450	1126430	42456	15816		11074	15.78333	58272	56.67
october	st.george	35000	42665	13590144	21418405.6	12642720	560376	223848		141456	172.4167	805968	611.954
novomber	st.george	35000	38456	12167424	17790500	11417616	425352	173568		128688	128.2667	621120	508.3
december	st.george	35000	42651	13510656	20835150	12641645	498096	209448		153643	168.35	715368	595.29
TOTAL	st.george	35000	448064	142151040	217690356	131749684	5553132	3089424		1522352	1631.85	8825988	6219.72