St. MARY'S UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF GENERAL BUSINESS ADMINISTRATION

THE EFFECT OF PLANT AND EQUIPMENT AINTENANCE STRATEGIES ON FACTORY PERFORMANCE: THE CASE OF BEVERAGE BOTTLING COMPANY, ASKU Plc.

By:

MENGISTU GIRMA ZEWUDIE

(ID.SGS/0043/2009A)

December, 2019
ADDIS ABABA

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THE THESIS SUBMITTED TO St. MARY'S UNIVERSITY, SCHOOL OF GRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF BUSINESS ADMINISTRATION

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APPROVED BY BOARD OF EXAMINERS

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Advisor Signature

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External Examiner Signature

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Internal Examiner Signature

DECLARATION

I, the undersigned, declare that this research is my original work; prepared under the guidance and orientation of Tiruneh Legesse (Asst. Prof.). All sources of materials used for the thesis have been duly acknowledged. I further confirm that the research has not been submitted either in part or in full to any other higher learning institution for the purpose of grade or earning degree.

____________________________ ____________________________

Name: Mengistu Girma Signature

St. Mary's University, Addis Ababa December, 2019

ENDORSEMENT

This research has been submitted to St. Mary's University, School of Graduate studies for examination with my approval as a university advisor.

Tiruneh Legesse (Asst. Prof.)   Signature

Advisor name   _________________

St. Mary's University, Addis Ababa   December, 2019

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Key to Acronyms

BCM = break down, corrective maintenance

PM = Preventive maintenance

PDM = Predictive maintenance

PRM = Proactive maintenance

COM = Cost of maintenance

FP = Factory performance

FPI = Factory performance indicator

FTE = Factory Time Efficiency

PBPY = Production of Bottles per Year

EqAv = Equipment Availability

CBM = Condition Based Maintenance

SBM = Statistical Based Maintenance

RCM = Reliability Centered Maintenance,

TPM = Total Productive Maintenance,

CM = Corrective Maintenance,

CBP = Current Best-Practice

AM = Autonomous Maintenance

FTM = Fixed-Term Maintenance

HR = Human Relations

HRM = Human resource management

JIT = Just-in-time

RCA = Root cause analysis

SPSS = Statistical Package for Social Science

RCFA = Root-cause failure analysis

RCM = Reliability-centered maintenance

ROFA = Return on fixed assets

TQM = Total quality management

RM = Raw Material

FG = Finished Goods

OEM = Original Equipment Manufacturer

ROI = Return on Investment

PI = Performance Indicator

KPI = Key Performance Indicator

CLIT = Cleaning, Lubrication, Inspection and Tightening

SOP = Standard Operating Procedure

KPI = Key Performance Indicator

CBM = Condition Based Monitoring

CMMS = Computerized Maintenance Management System

CCBA = Coca Cola Beverage Africa

EABSC = East Africa Bottling Share Company

HRs- Hours

ABSTRACT

The purpose of this research was to analyze the effect of plant and equipment maintenance on factory performance of beverage bottling company Asku Plc. The research was aimed specifically to identify plant and equipment maintenance strategies adopted, factors affecting factory performance and analyzing the relationship between the two and side by side identification of other factors affecting the factory performance was reached in conclusion. The four maintenance strategies' namely break down or corrective maintenance (BCM), preventive maintenance (PM), predictive maintenance (PDM) and proactive maintenance (PRM) related questioners were incorporated under each strategies. On the other side variables like cost of maintenance, factory time efficiency, production in bottles per year, and equipment availability related questioners under each variables were included. The research revealed that the maintenance strategies were found to have a positive correlation and have meaningful effects on the achievement of factory performance. It is observed that PM is the most factor affecting followed by BCM each with Likert score of 2.8784 and 2.7973. The survey also shown that the most monitored factory performance indicator and its mean weighted Likert score was production of bottles per year (3.49), while the least monitored was factory time efficiency (2.78). Influence of plant and equipment maintenance on the factory performance indicators was recognized by the respondents who acknowledged that four factory performance indicators were frequently affected by the maintenance tasks. A modern prevention technique called Total productive maintenance (TPM) activities which is involving operators in maintaining their own equipment, independent of the maintenance department must be aggressively implemented by the company.

***Key words*: Maintenance strategy, corrective maintenance, preventive maintenance, predictive maintenance, proactive maintenance, factory performance, availability, time efficiency, Asku Plc.**

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the Study

Nowadays, companies need to operate in highly dynamic environments where key resources are scarce and uncertainty in business opportunities is common (Battistoni et al., 2013). Like other companies nonalcoholic beverage industries are established for the purpose of making profits by the provider or owners of the enterprise (Omoniyi and Badeji, 2012). This implies in today's competitive environment business sustainability requires manufacturers need to capitalize on every possible advantage. Ethiopian industries are operating today in a business environment characterized by unprecedented global competition and technological change. In order to alleviate the problem of being unable to be competent in market and technology, maintenance strategies must be adopted to enhance plant performance which is important for the firms (Aregawi, 2014).
"Everybody does maintenance of one kind of another, but great maintenance requires a real strategic approach!" *(Vavra, 2016).*

Past and current maintenance practices in both the private and Government sectors would imply that maintenance is the actions associated with equipment repair after it is broken (Kumar and Suresh, 2008). The dictionary defines maintenance as "the work of keeping something in proper condition, upkeep." This would imply that maintenance should be actions taken to prevent a device or component from failing or to repair normal equipment degradation experienced with the operation of the device to keep it in proper working order. Maintenance is an important system in operation. In an era where industries are focusing on 24 hours operation to maximize production, plants and equipment are pushed to their absolute limit to cope with this demand. As utilization increases, the rate at which the machine parts get worn out increases thus the frequency of failure increases rapidly. To combat this problem and ensure that machines continue to operate at its optimum, maintenance work is carried out (Hasinda et al., 2012).

Successful companies of today have often a distinct expressed business idea connected to a strategy that explains it and also, how to reach it. Organizations are continuously looking for strategies to improve operations and gain competitive advantage. Fredriksson and Larsson (2012), define maintenance strategy as "the management method used in to achieve the maintenance objectives". Strategic maintenance is understanding all parts of the plant, attention it needs and when; and above all, how to make sure to take the machine down for maintenance on time, rather than when the machine wants to take itself down. When an equipment or machine breaks, it almost always is expensive and wasteful, and can be dangerous as well (Vavra, 2016).

In most Ethiopian manufacturing firms, it is widely known that maintenance currently is viewed by management as a big expense. The fact is, this is not an unusual opinion since maintenance does not include any value adding activities. But this is about to change. According to Frederickson and Larsson (2012), it is increasingly common for manufacturing industries to work with maintenance as a center point of profit. Thus, a greater knowledge of maintenance strategies and its ability for long term performance have increased the interest in the topic. It is all based on minimizing the downtime and the key to success is to ensure that maintenance strategies are properly being used. Hence, by applying the right strategy and striving to use maintenance practices there is a lot to gain. Wilson et al. (2000) coated in (Brah and Chong, 2004) argue that a properly executed maintenance program is a strategic tool that could ensure continued generation of benefits.

One of the main expenditure items of manufacturing companies is maintenance cost, which can make 15% to 70% of production costs, varying according to the type of industry (Bevilaqua and Bragila, 2000). Maintenance of plant and equipment has a strong impact on achieving a fully operational mode; hence, maintenance strategies represent a distinct sub-topic in the field of operations management (Gebauer et al., 2008). Shahin, Shirouyehzad and Pourjavad (2012). According to Ibid (2012), In manufacturing firms diverse problems exist that can influence the manufacturing cost, product quality and delivery time of products to customers; such as manufacturing technology selection, maintenance strategy selection, machine location and evaluation of quality function. Maintenance, as a system, plays a key role in decreasing cost, minimizing equipment downtime, enhancing quality, increasing productivity and providing reliable equipment and as a result, achieving organizational targets and objectives.

Though it is evident that many researches were carried out on the topics of plant and equipment maintenance strategies and performance of different firms (Mwanaongoro and Imbambi, 2014), on Kenya sugar industry (Shahin, Shirouyehzad and Pourjavad, 2012), on mining industry, (Nzewi, Chiekezie and Arachie, 2016), on Aluminium manufacturing industries of Nigeria and, other researches focused on effects of maintenance strategies (predictive and predictive types) on factory performance. However, there are limited researches done compatible with Ethiopian manufacturing industries, in particular on beverage bottling companies which relates the maintenance strategies (breakdown, preventive predictive and proactive maintenance strategies) on factory performance. This study emerges from the gap which concerns strategic maintenance adoption and the need for company to use resources more efficiently. Therefore, the purpose of this study was to study the effect of plant and equipment maintenance strategies on factory performance.

1.2 Statement of the Problem

In an increasingly competitive market place amongst the beverage industries, bottle filling industries in particular, show a clear and distinct need to improve their operations (Jeffries et al., 2003). A typical bottle filling production line generally includes arranging preforms, blowing and forming the bottle, filling, crowning, labelling, detection of the foreign bodies, and packing. For those industries an important aspect of successful performance is to ensure minimal breakdowns during operation time. The importance of maintenance for manufacturing systems, especially for continues manufacturing systems leads to adopt various maintenance strategies. According to Shahin, Shirouyehzad and Pourjavad (2012), there is no perfect maintenance strategy resulting that, selecting a strategy or a suitable combination of strategies has become one of the most important problems for maintenance managers. This implies each maintenance strategy might have strength and weakness. In addition, each maintenance strategy is applicable for a specific manufacturing system. Therefore, it needs to identify plant and equipment maintenance strategies adopted by Asku Plc.

In one or the other hand maintenance is not only technical aspect. It is the balance between technical and management responsibility within the long run. Since every strategic intent is within the hierarchical levels of the entire organization, the visibility of the company's goals and objectives from corporate or strategic level to the middle management at tactical level and throughout the organization (Parida and Kumar, 2009). Thus, top management and maintenance personnel must agree on prepared maintenance program. According to Shahin, Shirouyehzad and Pourjavad (2012), maintenance policy is a tool for maintenance personnel to plan their appropriate maintenance strategies and it requires strategic directions, as well as resources. Thus knowing the actual condition of maintenance strategy of the company is necessary.

Asku Plc. bottling company's different years' annual report clearly indicated that its overall productivity as per budgeted capacity for the past three consecutive budget years were 52.5%, 51.5%, and 47.2% which was not above 55% (Company annual report between 2015 to 2018). There are different factors expressed as: achievement of lower annual production of budgeted bottles. Reasons for poor performance were many, as per company annual and quarter reports; most of machine and plant line stoppages are due to sudden breakdown, cleaning activities, preventive activities, lubrication, minor repairs and replacements. Nzewi, Chiekezie and Achraie (2016), described maintenance culture in the organizations is possibly the reason why the organizations encounter frequent machine breakdown which makes the organizations unable to meet with the order placed by customers and reduction in the revenue of the firms. Thus it is most important to know which maintenance types are applicable to Asku Plc.

Some related previous researches were conducted on different manufacturing firms in general has indicated robust plant and equipment maintenance strategies play a key role on factory performance with positive relationship (Mwanaongoro and Imbambi ,2014; Parida and Kumar, 2009; Khan and Darrab, 2010; Nzewi, Chiekezie and Achraie, 2016). However, these studies focused on different firms than nonalcoholic beverage bottling industries and most of the studies are on performance and by selection of the right strategy for particular industry. The study was prompted by continued less performance achievement. It is therefore, the right to study the effect of plant and equipment maintenance strategies on factory performance of Asku plc.

1.3 Objectives of the Study

Below are general and specific objectives the research tried to achieve through the project and provided direction to the study.

1.3.1 General Objective

The key objective of this research was to analyze the effect of plant and equipment maintenance strategies on factory performance of Asku Plc.

1.3.2 Specific Objectives

The specific objectives of this research were:

1. To identify plant and equipment maintenance strategies adopted by Asku Plc.
2. To evaluate factors affecting factory performance of Asku Plc.
3. To analyze relationship between the plant and equipment maintenance strategies adopted and the factory performance of Asku plc.
4. To determine other factory performance factors which are influenced by plant and equipment maintenance strategies.

1.4 Research Hypotheses

H1: Breakdown maintenance has significant positive relationship with factory performance.

H2: Preventive maintenance has significant positive relationship with factory performance.

H3: Predictive maintenance has significant positive relationship with factory performance.

H4: Proactive maintenance has significant positive relationship with factory performance.

1.5 Definition of Terms

Maintenance: The combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to a state in which it can perform the required function (Växjö, 2010).

Maintenance Strategy: The management method used in order to achieve the maintenance objectives (Växjö, 2010).

Production: The process, which combines and transforms various resources used in the production/operations subsystem of the organization into value added product/services in a controlled manner as per the policies of the organization (Växjö, 2010).

Maintenance Cost: A major portion of the operating costs of production plants which is related to maintenance expenditures. Maintenance costs are impacted by both maintenance effectiveness and the efficiency with which maintenance is performed. (Alsyouf, 2004)

Availability: The probability that an item is available for use when required (Mobley, 2004).

Downtime: The total time during which the item is not in satisfactory operating state (Mobley, 2004).

Failure: The inability of an item to operate within the defined guidelines (Mobley, 2004).

Serviceability: The degree of ease or difficulty with which an item can be restored to its working condition (Mobley, 2004).

Cost performance: - the maintenance cost items include labor, materials, services, technical support and overheads which are assigned to a specific area of the operation, a job or other expense types which can be assigned to key parts, consumables and services (Alsyouf, 2004).

Process performance: - ratio of planned and unplanned work, schedule. Compliance maintenance management is a business process with cost inputs and equipment performance outputs. An optimal performance level needs to be established between these two variables. (Alsyouf, 2004)

1.6 Significance of the Study

This research will contribute primarily to and support the stakeholders like factory managers, business owners, and finances as a practical significance by clearly indicating the effect of strategic maintenance activities which firms should adopt and performance of factory they are expecting. Secondly for other similar industries' strategic makers it helps to recognize the relationship between the two and formulate their own. If plant and equipment maintenance strategies have relationship with factory performance, this research will shed light on the true value of maintenance strategies which plants should adopt and related performance indicators. Knowledge of the relationship will then enable practitioners to deliberately execute maintenance techniques to achieve the immense cost saving alluded to above. The last but not least is, this research will have a significant contribution for future research in this sector.

1.7 Scope of the Study

The study only focused on Asku Plc located in Oromia regional state west of Addis Ababa special zone in Burayu city administration which has more than 20 years' experience in Ethiopian beverage industry. Asku Plc. produces bottled water (Aquaddis), carbonated soft drinks (Royal Tonic, RC Lemonade, RC Orange), Juice (Ethiopicana) and gaseous or soda water (Addis Sparkling). It is aimed to focus on maintenance department and will thus not focus or take into account the work or decision-making process related to production. Further this master's thesis never included literature studies on the operational level of a maintenance organization; that is, theory of how tools and techniques are used were not considered.

1.8 Limitation of the Research

There was lack of proper, consistent and firsthand information from the factory side which were not match in terms of time period the researcher wanted to have because the data needed was often not specifically tracked or documented. The research review inputs like documents of weekly, monthly, quarterly, semi-annual and annual reports of the factory, which were secondary data. The demerit in this instance was that this data had been prepared and documented for some purposes other than to solve the problem at hand and some data was not used in our methodology. Due to this, the researcher relied mainly on questionnaire results and related researches conducted in another country to present the discussion of the research. On another hand, "performance" is one of the most argued concepts about which there has never been an agreement among various researchers and theorists, (Hashem S., 2015). Thus, the word performance is a very complex word consisting of numerous aspects that couldn't be treated into details.

1.9 Organization of the Study

This research was organized and presented in five main chapters by which the first one discusses briefly literatures related to maintenance strategies and factory performance and introduce the problem in brief. Related findings and their conclusions were taken into account. In this chapter, statement of the problem, possible causes, and consequence of the problem were critically evaluated. The research objectives, research hypotheses and significance of the study are included. Chapter two presented the literature that discuss issues pertaining to the factors that are relating maintenance strategies with factory performance. The methodology to be used for this research is discussed in chapter three, whereas chapter four covers entire result of the research findings and data analysis testing. The final chapter (chapter five) presents the conclusion and recommendations based on the research findings.

CHAPTER TWO

2. REVIEW OF RELATED LITERATURE

This part of the paper briefs summary of existing literature and is intended to address the first to third research question in-depth and fourth research question partly. In the part of literature review, the researcher reviewed the available theoretical literature and previous empirical research related to the study topic “plant and equipment maintenance strategies and performance”. This chapter includes sub sections like: theoretical review, empirical review, the conceptual framework, the critiques of existing literature, the summary and the research gaps. Simon (2011) quoted Boote and Beile (2004) as the literature review puts the research into a set with other studies and documents that have dealt with comparable issues. Thus, it is a thorough review of the literature which safeguards against undertaking a study that may have been conducted, may not be feasible to do, or might not be of much value when set against what needs to be researched in a particular field.

2.1 Introduction

The industry sector of Ethiopia contributes to about 4% of the overall economy, though it has shown some growth and diversification in recent years. (CSA, 2014: Abstract report of manufacturing survey). Much of this sector is concentrated in Addis Ababa and surrounding Oromia special zones. Thus, it is observed that the local market has become increasingly competitive and volatile which is resulting in the need for the players in the beverage industry to continuously improve their processes, especially on bottle filling and crowning operations. The food and beverages sector are one of the main components of Ethiopia’s manufacturing sector. The first round GTP I (2010-1015) ranked agro-processing industries among top priority industries. Based on official industrial statistics, the number of establishments under this subcategory are 670 and of those under private ownership accounts about 96% of the ownership title (CSA, 2014: Abstract report of manufacturing survey). Food and beverages constitute some 40 percent of the industry sector. Ethiopia's Growth and Transformation Plan II (GTP II) aims to spur economic structural transformation and sustain accelerated growth towards the realization of the national vision to become a low middle-income country by 2025. GTP II focuses on ensuring rapid, sustainable, and broad-based growth by enhancing the productivity of the agriculture and manufacturing sectors, improving the quality of production, and stimulating competition within the economy. In one of Ethiopian Maritu Legesse's popular songs there is a lyric that reads "Wusheten newu enji endiaw segedereder, enes lagere lij wuha shiche lider". Which can loosely be translated as "I have been hiding my feelings; but [for you], I would even [waste/spend my time] selling water." Asserting that she is willing even to sell water, which is too cheap to take to a market and to show that what she would like do for her loved one. Traditionally, selling water which was even as mentioned in the song was unimaginable, in the Ethiopian context. Now, things have changed, and water has become by far, one of the most sellable products in the country. Asku Plc. (The Nonalcoholic Beverage Industry) is doing its business basing on bottled water, different types of carbonated soft drinks, juice and recently started soda water production and selling. To be competitive in the market the production of those products through its machines must be efficient; this can be ensured by effective maintenance of its equipment and plant. According to Enofe and Aimienrovbiye (2010), Maintenance has had a tremendous impact on company's performance to optimize its production system in order to meet its long-term objectives. This is because according to Andrew S. et al. (2010), Maintenance is a key part of any business activity, since its principal objective is to preserve the availability of the assets that are used for the business.

2.2 Theoretical Literature Review

The necessary theories that are relevant for this research are presented in this section. The theoretical review entails the process or approach to this research with respect to the main aspects considered as significant to the scope of the study. The first step of the review begins with the assessment of different aspect in the plant directly related to maintenance, production equipment and processes leading to production profitability. It starts with describing plants and equipment different maintenance strategies, tasks and its impact; followed by describing factory performance indicators, the relationship between maintenance strategies, and performance; the relationship between maintenance tasks and performance indicators; other possible factors which can influence factory performance. This is all in view to increase the reader's understanding of the research.

The theoretical framework made is aimed to introduce maintenance and corresponding methodologies and philosophies within maintenance. It should also be used as a foundation of knowledge within the area of maintenance in order to develop a model for the formulation of a maintenance strategy.

2.2.1 Production Equipment and Plant Maintenance

Manufacturing plants have equipment and facilities that must be operational, often around the clock that require some type of maintenance. Past and current maintenance practices in both the private and government sectors would imply that maintenance is the actions associated with equipment repair after it is broken. With the competitive market of today, industry is forced to continuously increase its production efficiency. One important aspect of this is to optimize the maintenance of production equipment (Antti Salonen, 2009). Kumar and Suresh (2008) defines maintenance as “the work of keeping something in proper condition, upkeep.” This would imply that maintenance should be actions taken to prevent a device or component from failing or to repair normal equipment degradation experienced with the operation of the device to keep it in proper working order. The British Standard glossary of terms (3811:1993), Rastegari and Salonen (2013) defines maintenance as “The combination of all technical, administrative and management actions during the life cycle of equipment intended to retain it in, or restore it to a state in which it can perform the required function.” Dhillon, B. S. (2006) also defined maintenance as “All actions necessary for retaining an item or equipment in, or restoring it to, a specified condition.” This implies that when equipment and plant of an organization is restored to a specified condition it will serve i.e. machines are capable to produce. This increases the equipment operational life and productivity. Maintenance lengthens the life of equipment and reduces its failure rate (Jih-AN Chen, 2012).

The term maintenance has been defined as the combination of technical and associated administrative actions intended to retain an item or system in or restore it to a state in which it can perform is its required function (ISO 14224, 2006). Maintenance in its narrow meaning includes all activities related to maintaining a certain level of availability and reliability of the system and its components and its ability to perform a standard level of quality (Al-Turki et al., 2014).

Maintenance also includes engineering decisions and associated actions that are necessary for the optimization of specified equipment capability, where capability is the ability to perform a specified function within a range of performance levels that may relate to capacity, rate, quality, safety and responsiveness (Kumar et al., 2014). Thus, literatures are indicating development of the maintenance definition has been shifting from solely technical responsibility into the importance of the balance of both technical and management responsibility with time elapse.

2.2.2 Maintenance Types

According to Smith and Mobley (2003), a number of surveys conducted in industries throughout the United States have found that 70% of equipment failures are self-induced. Maintenance personnel who are not following what are termed "Best Maintenance Repair Practices" substantially affect these failures. According to Ibid (2003) between 30% and 50% of the self-induced failures are the results of maintenance personnel doing not know the basics of maintenance. Maintenance personnel who, although skilled, choose not to follow best maintenance repair practices potentially cause another 20% to 30% of those failures. According to Mobley (2004), the Industrial and process plants typically utilize two main types of maintenance management philosophies which are called run-to-failure, or preventive maintenance. Further, Alsyouf (2007) defined maintenance strategy is as the set of various maintenance interventions (corrective, preventive, predictive, proactive, etc.)

2.2.2.1 Breakdown (Corrective) Maintenance (BCM)

Breakdown maintenance is fall under run to failure (RTF) maintenance (British Standard 3811:1993 Glossary of terms). Run to Failure Maintenance (RTF) According to Dhillon (2006), RTF maintenance is the required repair, replacement, or restore action performed on a machine or a facility after the occurrence of a failure in order to bring this machine or facility to at least its minimum acceptable condition. It is the oldest type of maintenance and is subdivided into two types as emergency maintenance and breakdown maintenance. Where emergency maintenance is carried out as fast as possible in order to bring a failed machine or facility to a safe and

operationally efficient condition and breakdown maintenance is performed after the occurrence of an advanced considered failure for which advanced provision has been made in the form of repair method, spares, materials, labor and equipment.
Usually, corrective maintenance is an unscheduled maintenance action, basically composed of unpredictable maintenance needs that cannot be preplanned or programmed on the basis of occurrence at a particular time. The action requires urgent attention that must be added, integrated with, or substituted for previously scheduled work items. This incorporates compliance with "prompt action" field changes, rectification of deficiencies found during equipment/item operation, and performance of repair actions due to incidents or accidents (Dhillon, 2006).

2.2.2.2 Preventive Maintenance (PM)

Wireman (1990, p.98), defines preventive maintenance as "...any planned maintenance activity that is designed to improve equipment life and avoid any unplanned maintenance activity." It is a set of activities that are performed on plant equipment, machinery, and systems before the occurrence of a failure in order to protect them and to prevent or eliminate any degradation in their operating conditions. Systematic inspection, detection, correction, and prevention of incipient failures, before they become actual or major failures. Preventive maintenance (PM) is an important component of a maintenance activity. Within a maintenance organization it usually accounts for a major proportion of the total maintenance effort. PM may be described as the care and servicing by individuals involved with maintenance to keep equipment/facilities in satisfactory operational state by providing for systematic inspection, detection, and correction of incipient failures either prior to their occurrence or prior to their development into major failure (Dhillon, 2006).

Some of the main objectives of PM are to: enhance capital equipment productive life, reduce critical equipment breakdowns, allow better planning and scheduling of needed maintenance work, minimize production losses due to equipment failures, and promote health and safety of maintenance personnel (Niebel, 1994).The PM approach to maintenance management is predominantly recurring or time-driven tasks performed to maintain acceptable levels of availability and reliability (Mobley, 2002).According to Smith and Hawkins (2004), the advantage of applying preventive maintenance activities is to satisfy most of maintenance objectives.

a. It is good for those machines and facilities which their failure would cause serious production losses.
b. Its aim is to maintain machines and facilities in such a condition that breakdowns and emergency repairs are minimized.

It is main activities include replacements, adjustments, major overhauls, inspections and lubrications.

2.2.2.3 Other Types of maintenance: Reliability Centered Maintenance (RCM)

Reliability centered maintenance (RCM) is a systematic process used to determine what has to be accomplished to ensure that any physical facility is able to continuously meet its designed functions in its current operating context. RCM leads to a maintenance program that focuses preventive maintenance (PM) on specific failure modes likely to occur. Any organization can benefit from RCM if its breakdowns account for more than 20 to 25% of the total maintenance workload (Dhillon, 2006).

2.2.2.3.1 Predictive Maintenance (PDM)

Predictive maintenance is a set of activities that detect changes in the physical condition of equipment (signs of failure) in order to carry out the appropriate maintenance work for maximizing the service life of equipment without increasing the risk of failure. PDM monitors the performance and condition of equipment during normal operation to reduce the likelihood of failures.
It is classified into two kinds according to the methods of detecting the signs of failure:

a. Condition-based predictive maintenance (CBM)
b. Statistical-based predictive maintenance (SBM)

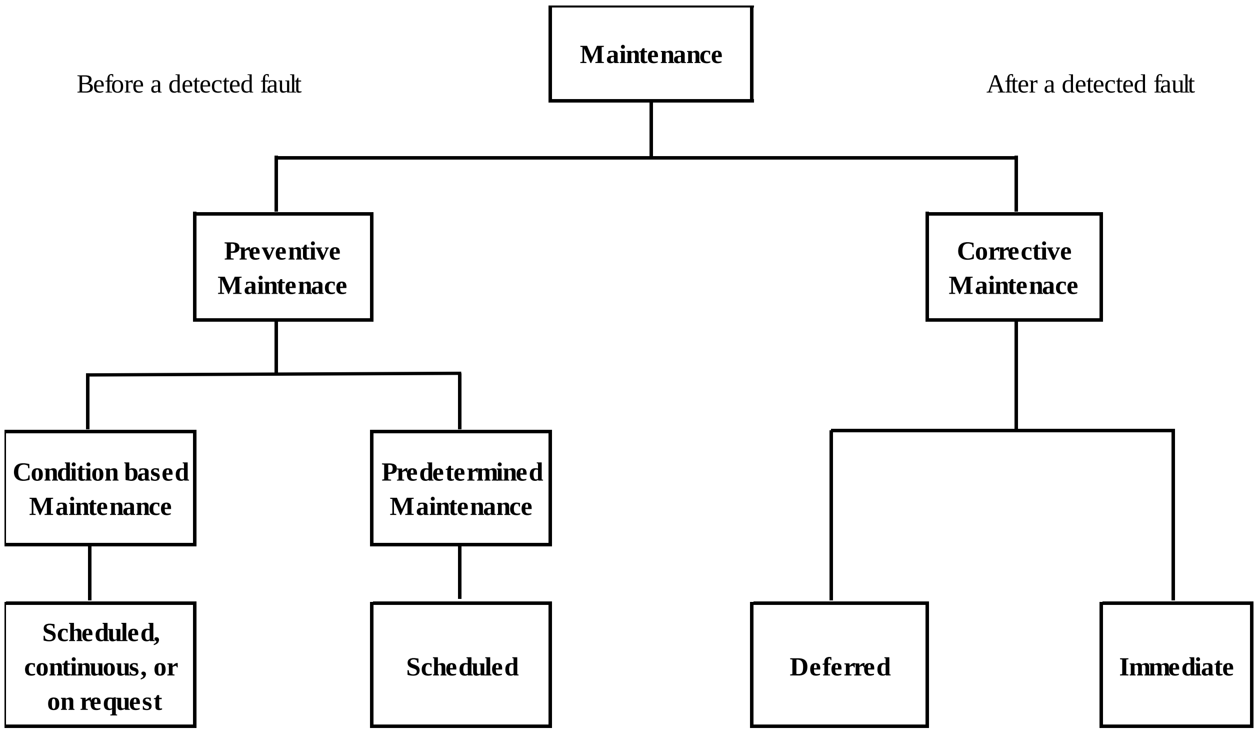
According to Dhillon (2006), condition-based predictive maintenance (CBM): "Preventive maintenance based on performance and/or parameter monitoring and the subsequent actions." (SS-EN 13306, 2001, p.15). The idea behind CBM is to assess the condition of technical systems and/or components by monitoring its condition, and perform maintenance only when potential failures are predictable. It depends on continuous or periodic condition monitoring equipment to detect the signs of failure. Statistical-based predictive maintenance (SBM) depends on statistical data from the meticulous recording of the stoppages of the in-plant items and components in order to develop models for predicting failures.

2.2.2.3.2 Proactive Maintenance (PRM)

This type of maintenance helps improve maintenance through actions such as better design, use of original equipment manufacturers (OEM) parts, workmanship, installation, scheduling, and maintenance procedures. The characteristics of proactive maintenance include practicing a continuous process of improvement, using feedback and communications to ensure that changes in design/procedures are efficiently made available to item designers/management, ensuring that nothing affecting maintenance occurs in total isolation, with the ultimate goal of correcting the concerned equipment forever, optimizing and tailoring maintenance methods and technologies to each application. It performs root-cause failure analysis and predictive analysis to enhance maintenance effectiveness, conducts periodic evaluation of the technical content and performance interval of maintenance tasks, integrates functions with support maintenance into maintenance program planning, and uses a life cycle view of maintenance and supporting functions (Dhillon, 2006).

Basic methods employed by proactive maintenance to extend item/equipment life are root-cause failure analysis which is concerned with proactively seeking the basic causes of facility/equipment failure and age exploration provides a mechanism to vary a maintenance program’s key aspects to optimize the process and examines the applicability of all maintenance tasks. Specifications for New/Rebuilt Item/Equipment: the basic concern is with writing effective specifications, documenting problems, and testing the equipment of different vendors. Recurrence control concerns the control of repetitive failures.

Fig.1 - Maintenance Classification



Source: Rastegari and Salonen (2013)

2.2.2.4 Total Productive Maintenance (TPM)

It is not uncommon that the maintenance and operations departments are the largest departments, and each comprises 30 per cent of the total manpower. Furthermore, next to the energy costs, maintenance costs can be the biggest part of any operational budget. The role of maintenance in modern manufacturing systems is becoming even more important, with companies adopting maintenance as a profit-generating business element. The basic practices of TPM implementation are often called the pillars or elements of TPM. The TPM concept is built and stands on eight pillars (Sangameshwran and Jagannathan, 2002). TPM initiatives, as suggested and promoted by the Japan Institute of Plant Maintenance (JIPM), involve an eight-pillar implementation plan that results in substantial increase in labor productivity, reduction in maintenance costs and reduced production stoppages and downtimes. TPM is designed to maximize equipment effectiveness (improving overall efficiency) by establishing a productive-maintenance system covering the entire life of the equipment, spanning all equipment related fields (planning, use, maintenance, etc.) and, with the participation of all employees from top management down to shop-floor workers, to promote productive maintenance through motivation management or voluntary small-group activities (Al-Turki et al., 2014). Fredriksson and Larsson (2012) describes TPM "as a proactive and cost-effective approach to maximize equipment effectiveness using the principles of teamwork, empowerment, zero breakdowns, zero defects and zero accident".

2.2.2.5 Autonomous Maintenance (AM)

Autonomous Maintenance refers to one pillar of the TPM activities that involve operators in maintaining their own equipment, independent of the maintenance department. The principal way in which the production department participates in TPM is through autonomous maintenance-cleaning, inspection, and simple adjustments performed by operators systematically trained through a step-by-step programme. According to Taylor (2011), Autonomous maintenance is a technique to get production workers involved in equipment care, working with maintenance to stabilize conditions and to stop accelerated deterioration. Taylor (2011), further clarifies that the company must teach operators about equipment function and failures, including prevention through early detection and treating abnormal conditions in order to maximize the machine efficiency there by increasing the production outputs.

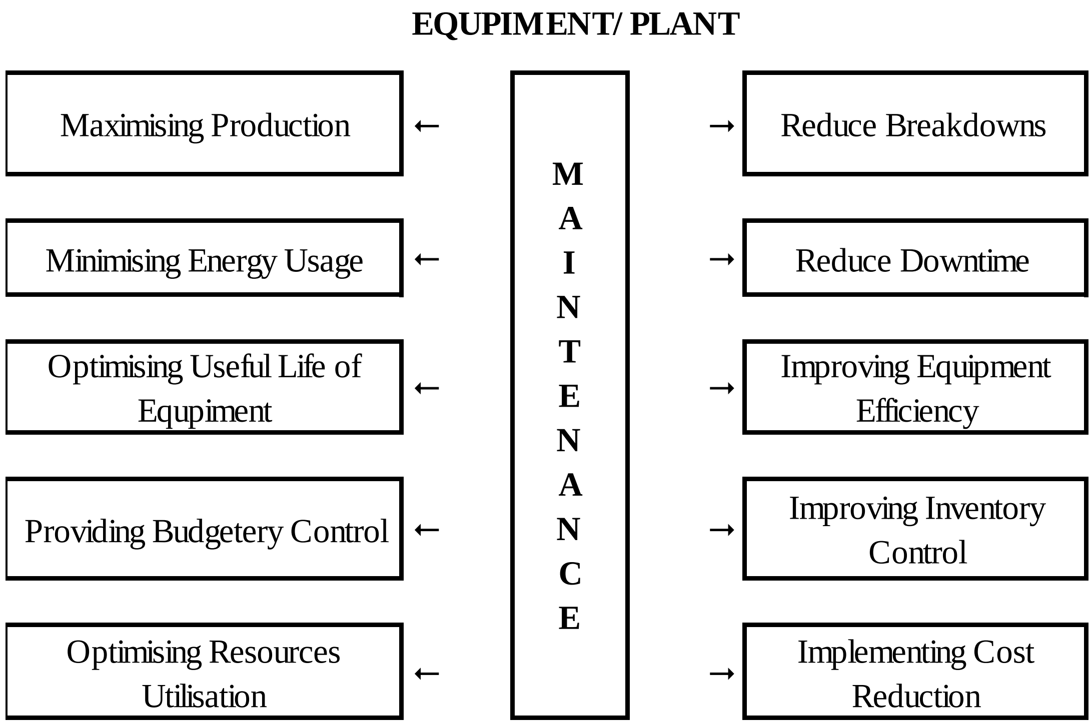
Autonomous maintenance of TPM implementation will also significantly increase the production performance, employee morale and job satisfaction (Ohunakin and Leramo, 2012). Operators in the shop floor must be involved in maintenance operations to solve problems as early as possible and eliminate most of the waste like time waste, downtime losses, etc. in autonomous maintenance (Almeanazel, 2010). Autonomous maintenance can also reduce major breakdowns, setup and adjustment losses and improve productivity, product quality and OEE of equipment (Jain et al., 2013a).Implementing AM thus made Operators and maintenance personnel to continue to refine the inspection process and to generate improvements that increase the equipment life and effectiveness. They are increasingly involved with maintenance in gathering and analyzing equipment data such as the results of daily inspection, downtime statistics, oil and grease usage, quality defect data, and tool wear records etc. They continue to build analytical and diagnostic stills by working on increasingly challenging improvement projects that reflect cooling improvement goals, such as reliability and maintainability improvement or quality activities. At this stage, the operators become full partners in the equipment management process and zero down time and zero defects become achievable targets.

2.2.3 Maintenance Objectives

Equipment and plant maintenance objectives are the targets assigned to or accepted by the management and maintenance department. These targets may include availability, cost reduction, product quality, environment preservation, safety. Khairy (2008), describes the key maintenance objectives as "total asset life cycle optimization which means maximizing the availability and reliability of the assets and equipment to produce the desired quantity of products, with the required quality specifications, in a timely manner and this objective must be attained in a cost-effective way and in accordance with environmental and safety regulation. This is therefore maintenance of equipment and plants mainly aimed for achieving the best performance for the company's equipment and facilities, reduction of the risks resulted from operation conditions to minimum levels and execution of requested maintenance for the equipment and project facilities with the maximum efficiency and least possible cost. According to International Federation of Automatic Control (2016), low productivity, downtime, and poor machine performance is often linked to inadequate plant maintenance, which in turn can lead to reduced production levels, increasing costs, lost market opportunities, and lower profits (Jonsson, 2000; Cholasuke et al., 2004; Saniuk et al., 2014; Saniuk et al., 2015). Thus, a production system in which maintenance is not given attention may easily lead to the system producing defective product as a result of machine defect.

Literatures reviewed by Simões, Gomes and Yassin, (2011) indicated that from the perspective of the maintenance manager, maintenance resources are finite, and usually below the level they should be. Production stoppages, breakdowns, power stoppages, shortage in manpower, lack of materials (supply), demand (external) and others business factors directly or indirectly affect the level of production. This tends to make maintenance scheduling a dynamic and challenging process. As such, the limited capacities and resources have to be shared, rather than competed for.

Figure 2. Equipment/Plant Maintenance Importance



Source: William J. Stevenson (2015 P.58)

2.2.4 Equipment and Plant Maintenance Strategies

Strategies are plans for achieving organizational goals. Organizational strategy is important because it guides the organization by providing direction for, and alignment of, the goals and strategies of the functional units. Moreover, strategies can be the main reason for the success or failure of an organization. When strategies are adopted performance of organization will be enhanced (Stevenson, 2015). Rastegari and Salonen (2013), states that “the strategy reflects the organizations conception of its intended long – term goal and the approach to achieve it”. According to Bergman and Klefsjo (2010), the content in the maintenance strategy is a mix of techniques and/or policies which depends on factors such as the nature of the plant, the maintenance goals or the equipment that will be maintained, the work environment and the work flow patterns (product focus, process focus). Crespo Marquez and Gupta (2006), Salonen (2011) state that maintenance strategies are a means to transform business priorities into maintenance priorities.

Maintaining the production capability of an organization is an important function in any production system. Stevenson (2015) expressed in his book that operations management strategic role in many strategic decisions in business organizations. The author noticed that most of them have cost implications as per table 2.1.

Table 2.1. Strategic operations management decisions

No.	Decision area	What the decision affect
1	Product and service design	Costs, quality, liability and environmental issues
2	Capacity	Cost structure, flexibility
3	Process selection and layout	Costs, flexibility, skill level needed, capacity
4	Work design	Quality of work life, employee safety, productivity
5	Location	Costs, visibility
6	Quality	Ability to meet or exceed customer expectations
7	Inventory	Costs, shortages
8	**Maintenance**	**Costs, equipment reliability, productivity**
9	Scheduling	Flexibility, efficiency
10	Supply chains	Costs, quality, agility, shortages, vendor relations
11	Projects	Costs, new products, services, or operating systems

Source: William J. Stevenson (2015 P.52)

Campbell and Reyes-Picknell, (2006); Bergman and Klefsjö, (2010); Fredriksson and Larsson (2012), A strategy is the idea of how to reach the objectives which means to take different steps or performing activities. The overall direction, a plan which describes the activities to be performed is described by the strategy. Maintenance Strategy is **“**The management method used in other to achieve the maintenance objectives” (Enofe and Aimienrovbiye, 2010).

Lee and Scott (2009) described maintenance strategy as “in general it includes corrective, preventive or condition-based maintenance”. However, there are different views on choosing appropriate maintenance strategy. Among various maintenance strategies, the effectiveness of planned preventive maintenance (PPM) is more challenged by the top management.

Maintenance policy (tool for maintenance implementation) which is result of strategic direction consists five major components (CEM, 1994; RICS, 1990; Chanter and Swallow, 1996; Lee and Wordsworth, 2001) are as follows:

- The length of time for maintaining equipment and plants for their present use.
- The life requirements of the equipment and plants and services.
- The standard to which the equipment and plants are to be maintained.
- The reaction time required between defects occurring and a repair being carried out.
- The legal and statutory requirements shall also be considered.

2.2.5 Maintenance Performance

Maintenance productivity aims at minimizing the maintenance cost dealing with the measurement of overall maintenance results/performance and maximizing the overall maintenance performance. Some of the measures of maintenance performances are availability, mean time between failures (MTTF), failure/breakdown frequency, mean time to repair (MTTR) and production rate index. Maintenance productivity indicators measures the usage of resources, like; labor, materials, contractors, tools and equipment. These components also form various cost indicators, such as man power utilization and efficiency, material usage and work order. Control of maintenance productivity (MP) ensures that the budgeted levels of maintenance efforts are being sustained and that required plant output is achieved (Kelly, 1997). Maintenance productivity deals with both maintenance effectiveness and efficiency.

For the process industry, machine downtime in the shop floor is one of the main issues for maintenance productivity. Unlike operational activities, maintenance activities are mostly non-repetitive in nature. Therefore, all maintenance personnel and managers face new problems with each breakdown or downtime of the plant or system, which needs multi-skill levels to solve the conflicting multi-objectives issues.

Maintenance performance is measured by establishing overall equipment effectiveness (OEE) (Kister et al., 2006).

Availability (A): - is all the operating time available minus all forms of no-operating time such as planned and unplanned downtimes. According to Taylor (2011), Availability is the percentage of time that equipment is available or ready for production, after all deducting scheduled and unscheduled downtime. Note that idle time caused by lack of product demand isn't deducted from the total time available. The equipment is considered "available" even though no production is demanded.

Availability = (loading time-downtime)/ (loading time)

Performance rate (P): - is based on the operating speed rate and the net operating time. The operating speed rate is the ratio of standard cycle time to the actual cycle time.

Operating Speed Rate = (Standard cycle time)/ (Actual cycle time)

The net operating time is the actual time the equipment operated within a specified period.

Net Operating Time = (Output*Actual Cycle Time)/ (Loading Time-Downtime)

Performance = Operating Speed Rate*Net Operating Time (Shirose, 1984:49-51)

Quality Rate: - is the ratio of conforming product to the total product produced (Campbell, 2006:161).

Quality Rate = (Total Product Produced-Reject product)/ (Total Product produced)

Then: -

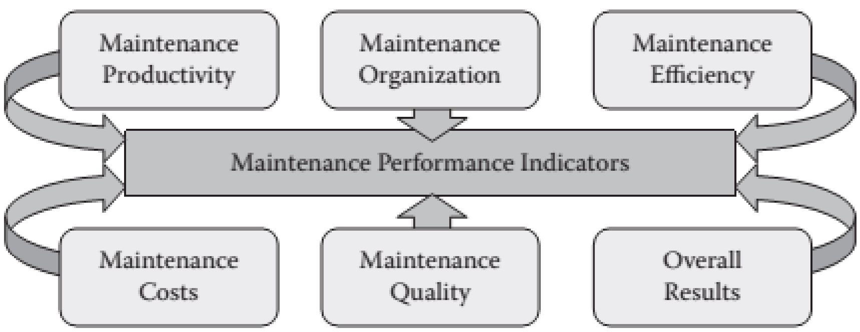
OEE = Equipment availability (%) *Performance Efficiency (%) *Rate of Quality (%)

OEE is a method to understand the performance of the manufacturing area, but also to identify possible limitations (Hansen, 2002). OEE calculates the percentage effectiveness of the manufacturing process. OEE is further a function consisting of the three factors, availability, performance efficiency and quality (Fredriksson and Larsson, 2012).

Overall Equipment Effectiveness can be used on all type's equipment (Shirose, 1992). The importance of equipment and process performance on the bottom-line results are recognized and these measures drive productive maintenance and OEE which include availability of equipment, performance rates and quality rates.

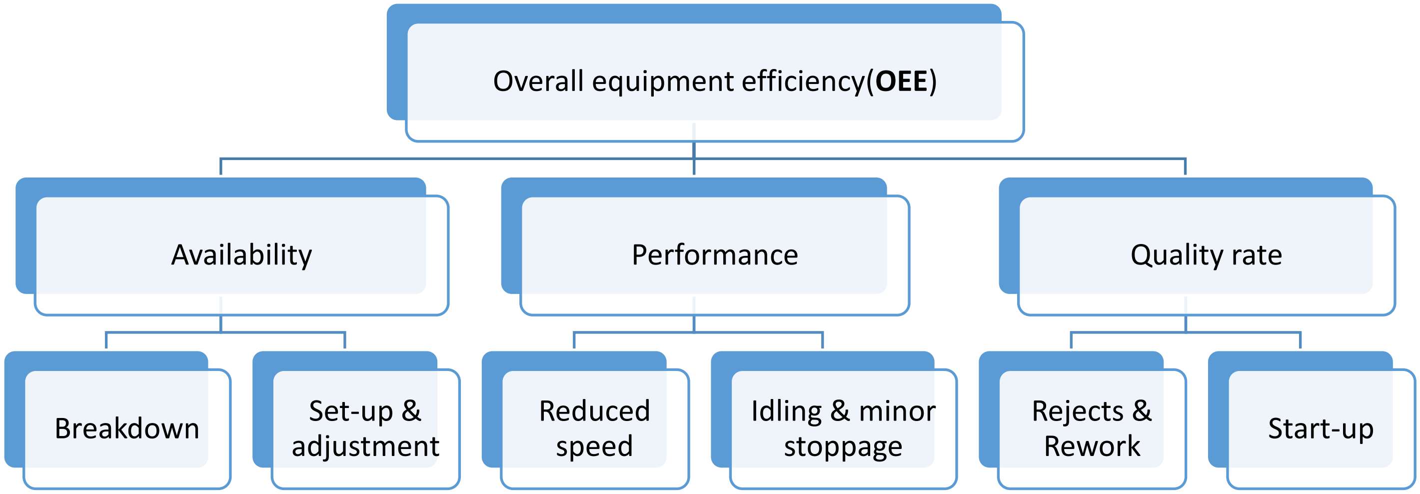
One of the goals of total productive maintenance (Shirose, 1992:37-48) is to improve equipment efficiency. This can be achieved by making the most of the functions and performance features of the equipment or by eliminating the six big losses which are obstacle to efficiency.

Figure 3. Maintenance Performance Indicator



Source: Taylor (2011, P85)

Figure 4. Six big losses.



Source: Kenney (2002)

2.2.6 Factory Performance

Performance is the level to which a goal is attained (Alsyouf, 2004). According to Campbell et al (2006), the manufacturing performance measurements that are applicable to this study are: -

Cost performance: - maintenance costs associated with a specific area include labor, material, services and technical support costs.

Equipment Performance: - the OEE of each critical piece of equipment in an area. The reliability and maintainability will also be used as a measurement of equipment performance.

Process Performance: - the percentage of planned versus unplanned maintenance activities will be compared.

Safety: -the quantity of accidents will confirm if the operators have been trained to identify when performing the autonomous maintenance activities.

2.2.7 Factory Performance Indicators

The role of maintenance in long term profitability of an organization has long been known, leading to researcher and practitioner to develop maintenance strategies that contribute to long term company's profitability. Hallgren (2007), It is difficult to fairly assess manufacturing performance. Financial measures, such as ROI, profitability etc., are usually plant level measures that are subject to many factors outside the scope of manufacturing operations. An attempt to isolate the performance of the operations function is to utilize measures where the management of operations plays an integral part, i.e. operational performance measures. "It is not possible to manage what you cannot control and you cannot control what you cannot measure!" (Peter Drucker)

Maintenance is an essential support function in an organization's value chain. When manufacturing organizations choose to compete in the global market, they usually use several competitive priorities, such as cost, quality, flexibility, and other competitive methods contingent on their manufacturing processes capabilities. Therefore, the readiness and availability of manufacturing equipment becomes critical, thus making maintenance an integral part of the manufacturing management process. This in turn can influence competitive priorities, and hence the achievement of the business strategy (Pinjala et al., 2006).

A Performance Indicator (PI) is used for the measurement of the performance of any system or process. A PI compares actual conditions with a specific set of reference conditions (requirements) by measuring the distances between the current environmental situation and the desired situation (target) (Parida and U. Kumar, 2009). The product of maintenance is reliability. A reliable asset is an asset that functions at the level of performance that satisfies the needs of the user. Reliability is assessed by measuring failure, Al Weber, (2005).

According to Campbell et al (2006:175-177) the maintenance measurements can be grouped under the heading: -Maintenance maximizes its effectiveness by ensuring that it performs "The Right Work at the Right Time". Mobley (2004), emphasized that the major expenses associated with breakdown maintenance (run to failure management philosophies) are: (1) high spare parts inventory cost, (2) high overtime labor costs, (3) high machine downtime, and (4) low production availability. That leads the performance of production plants to decline. Since there is no attempt to anticipate maintenance requirements, a plant that uses true run-to-failure management must be able to react to all possible failures within the plant. Proactive maintenance means intervening before the failure event occurs. The impact of proactive maintenance is not only to minimize the safety, environmental and operational consequences of failure but also to reduce the cost of maintenance by reducing secondary damage. For example, if the potential failure of a pump bearing was detected proactively, the catastrophic failure of the bearing could be prevented. The catastrophic failure of the pump bearing would likely result in damage to the casing, wear rings, impeller, mechanical seals, etc. The corrective repair would require an extensive pump rebuild. Utilizing a proactive task such as vibration monitoring to detect the bearing deterioration permits the scheduled replacement of the bearing prior to the occurrence of secondary damage. Less secondary damage means that it takes less time to repair (labor savings) and consumes fewer parts (material savings). The overall effect is the repair costs much less.

Maintenance costs are also impacted by increasing the efficiency of maintenance. These efficiency gains are achieved through improved planning and scheduling of "the right work at the right time". Published data suggests that companies with estimated wrench times of 25% to 30% can increase wrench time to between 40% and 60% through better planning and scheduling.

Table 2.2 Examples of internal and external measures of operational performance.

Operational performance Dimension	**Internal performance measures**	**External performance measures**
Quality	Rework cost, percentage of passed quality inspection, cost of quality control	Conformance to specification agreed upon, product performance
Delivery	Production lead time, accuracy of inventory status, dependability of internal lead times	Delivery lead time, on-time deliveries, stock availability
Cost	Unit cost of manufacturing, inventory turnover, capacity utilization, yield	Product selling price, market price
Flexibility	Set up time/cost, length of fixed production schedule, amount of operating capacity,	Product range, number of products offered, ability to handle volume and product mix changes

Source: Mattias Hallgren (2007)

Nevertheless, performance measurement is frequently argued that performance measure should be derived from strategy to reinforce certain strategy objectives (Skinner, 1989) in finding solutions to questions such as efficiency and effectiveness, customer satisfaction and value added (Amaratunga et al., 2002). Galvin and McGlynn, 2003, added that performance measurement is not only to identify the means for improvement but also to develop a path way for improvement (Dey et al, 2008). Insofar the improvement as to be reached, new performance measurement systems such as balanced score-card (BSC) (Kaplan and Norton, 1992, 1996), the strategic management analysis and report techniques (SMART) system known as performance pyramid (Cross and Lynch, 1988/1989), and the performance measurement questionnaire (Dixonet al.,

1990) has been proposed and implemented in the performance measurement (Dey et al., 2008). According to Neely et al., 2000, one common key weakness of performance measurement system adopted by many organizations is being overly narrow or even uni-dimensional in focus. Thus, there is a need for a framework that can help to offer performance measurement for improving performance in the process and how to evaluate the performance measure by applying strategic tools. Amongst all these management frameworks, the balanced score-card is chosen which encompasses all issues related to managing organizational activities for better performance.

2.2.8 Plant and Equipment Maintenance Strategies and Factory Performance

Measuring maintenance productivity performance is critical for any production and operational company, hence, a measure commonly used by industries is the maintenance performance for measuring the maintenance productivity, (Ben-Daya et al., 2009). Industries are facing a lot of challenges such as optimization of operation and maintenance function due to the continual evolving world of technologies, global competitiveness, environmental and safety requirements. The concern towards total quality and profitability of an organization are crucial factors in the business. It is evident that industrial maintenance function has gained high recognition over the last few decades in various industries. Consequently, over the years, many different strategies have been developed to support maintenance management implementation in the industry (Swanson, 2003).

The role of equipment maintenance in controlling quality, quantity and reducing costs is more evident and important than ever (Jay et al., 2006). The selection of an appropriate maintenance strategy is important as well as complex in maintenance management and the output of maintenance is hard to measure and quantify (Chris and Wang, 2001).Ensuring cost effective plant operation such as efficient and quality production, equipment availability and employee and environmental safety depends on how the organizations are able to effectively integrate maintenance function with other functions in the organization. Therefore, for organization to survive in the present industrial environment, healthiness of equipment with sustainable operations should be ensured (Ben-Daya and Duffua, 1995, Al-Najjar et al., 2001; Bennett, 2006).

Maintenance is not just ensuring healthiness of equipment in a facility but it also plays a crucial role in achieving organization's goals and objectives with optimum maintenance cost and maximum production.

Traditionally, maintenance management was dealt with the short-term issues like resources, cost, manpower etc. Recent past, maintenance management has changed its concerns towards the consideration of long-term goals like competitive, sustainability and strategy (Duffua et al., 2002). Maintenance function needs to be viewed as a strategic function in an organization. Therefore, there is a scope of improvement in the formulation of maintenance strategies for the organization, selection of particular maintenance strategy of the specific equipment or process and effective implementation of maintenance strategies selected.

2.3 Empirical Literature Review

According to Oseghale, (2014) research done under title "Impact of Maintenance Strategies on the Performance of Industrial Facilities in Selected Industrial Estates in Lagos State, Nigeria"; The study on industrial facilities of selected industries of Lagos, Nigeria, the finding reveals that in all the case of reactive maintenance strategy, that there is a weak positive correlation between reactive maintenance and the performance of the industrial facilities. The most widely maintenance strategy used by maintenance department of building manufacturing and plastic industries in Lagos state was reactive maintenance. A weak positive correlation was established between maintenance strategy adopted and the performance of industrial facilities. The study concluded that a week correlation between maintenance strategy and industrial performance. This is the reason why the researcher has selected different sectors of buildings and facilities within, services, manufacturing plants which were different in equipment types, nature of operation and way to approach too.

As per the study on sugar firms of Kenya by Mwanaongoro and Imbambi (2014); " Assessment of Relationship between Plant and Equipment Maintenance Strategies and Factory Performance of the Kenya Sugar Firms ", which the study revealed that robust plant and equipment maintenance play a key role in the industry performance. Key factory performance indicators were found to be industry time efficiency (4.27), the least monitored was tones sugar recycled or rejected (2.73).

Infrequent monitoring of capacity utilization may lead to uneconomical operation and hence high cost of production. The cost of maintenance of plant or equipment may reveal whether it is prudent to continue operating a plant or purchase a new and better technology oriented plant. Maintenance is synonymous with high level of availability, reliability and operable assets which are linked directly to production capacity, productivity and business profit. The study lacks empirical implications of related studies and is basing on 10 sugar industries whose sample size is random with 6 population size from each industries with no reasons of neither exclusion nor inclusion well narrated.

The research undertaken, "Effective Preventive Maintenance Scheduling: A Case Study" (Hasnida Ab-Samat et. al, 2012), the implementation of preventive maintenance (PM) has proven that machine failure rates can be greatly reduced; ensuring uninterrupted production. In most companies, PM is not always carried out on schedule due to the circumstances involved and this affects the sole purpose of carrying out PM which requires precise planning on maintenance dates for each machine. However, based on the situation in the company, it was evident why the preventive maintenance work could not be carried out efficiently. In the case study company, the downtime data and analysis has shown the list of critical machines and the ineffectiveness of the current maintenance schedule that does not distinguish between the critical and non-critical machines. A further root cause analysis has shown that the machines suffer critical breakdowns when maintenance work is not done properly. Thus to prove this, the root cause analysis was done to show how each problem correlates with issues such as wear and tear and the delay to replace worn out components that lead to breakdowns.

A thesis on relationship between machinery maintenance and production performance in the case of East Africa bottling share company by (Desta Alem, 2018), the researched concluded that for EABSC to reduce maintenance cost and increase production output, minimizing the downtimes of an electrical power supply and the level of understanding of autonomous maintenance throughout the staff is mandatory. The machine efficiencies should be improved by improving the maintenance practices of autonomous maintenance and implementation of maintenance strategies and philosophies such as predictive maintenance system throughout the operation. The key factor which contributes for the machines not to produce as required has to be controlled and managed.

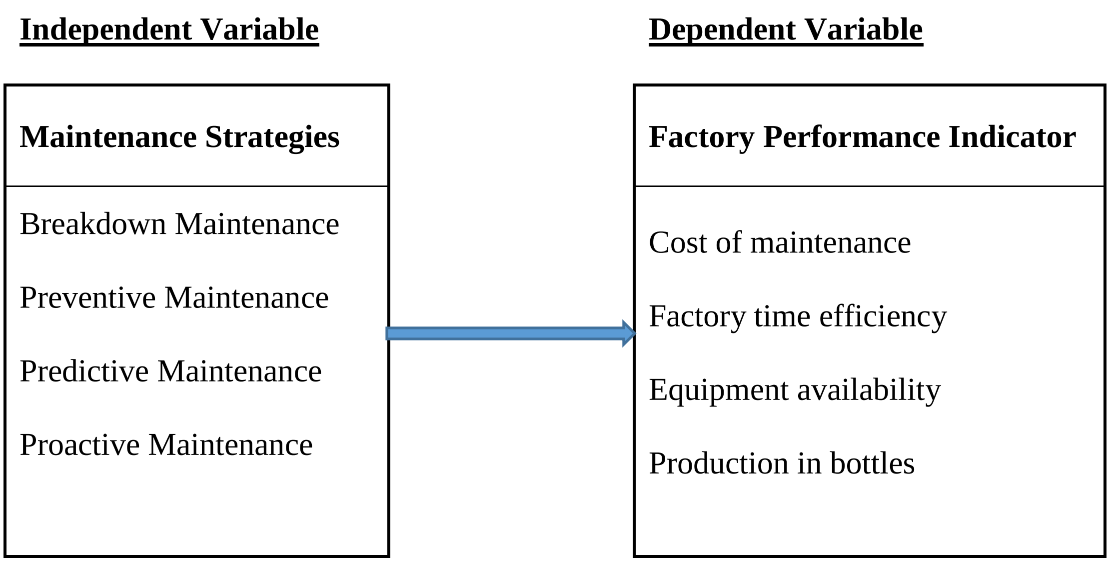
Operational failures need to be properly managed, the challenges which affect to equipment failure like individual capabilities and their competency, in adequacy of spares, distance of spare part store from production area, the time and priority given to maintenance planning and the reporting mechanism need to be given a due emphasis in order to get a production performance to a level of world class exceptional international performance. The study is done both from existing factory reports data and qualitative interpretations. The difference was not well interpreted and more over the researcher would have been concentrated on real data on hand rather than mixing up both.

The research on maintenance strategies on the viability of beverage industries in south-east Nigeria (CHIAKA, 2019) under title of "Equipment Maintenance Strategies On The Viability Of Beverage Industries In South-East Nigeria" found out that there are many maintenance approaches to equipment used by both firms ranging from preventive, corrective, mixed/integrated, and equipment tracking. The findings are in line with the contingency management theory which believes that there is no best way of getting things rather depending on the situation. Both firms use other maintenance approaches such as mixed/integrative maintenance, run-to-breakdown maintenance etc. On the findings of PMS and CMS on product quality and operating cost, the findings reveal that both strategies have a positive effect on; productivity, unnecessary shut-down, equipment efficiency, operators safety, minimize wastages and product availability. The study, therefore, concludes that there exist significant relation between PMS and product quality, operating cost on one hand, and CMS and product quality, and operating cost on the other hand.

2.4 Summary and Conceptual Framework

Maintenance remains one of the very few areas through which significant increase in company profits can be achieved. Mc Guin (2008), observes that "Robust Maintenance Capacity can be the difference between ongoing profits and impending downfall". The independent variable is the factory maintenance strategy while the dependent variable is the factory performance which is the primary interest variable. The researcher sought to establish the relationship between the independent and dependent variables which guided the study as summarized in the conceptual framework model, figure 5 below**.**

Figure 5. Conceptual Frame work



Source: Review of literature (Own)

CHAPTER THREE

3. RESEARCH DESIGN AND APPROACH

3.1 Research Design

The research presented in this document sets out to investigate properties of, and relationships between, aspects of manufacturing operations. This is done by theoretical reasoning and conceptual modelling but also using large-scale survey based empirical methods to test and develop theory. Descriptive statistics, and correlation analysis were applied to examine the effect of plant and equipment maintenance strategies and factory performance.
The collected data was summarized and analyzed to reach into a meaningful conclusion and recommendation.

Miller's (1991), explained descriptive research is the process of collecting data in order to answer questions concerning the current status of the subject matter. Saunders (2009) says that descriptive research portrays an accurate profile of persons, events or situations. This design offers to the researchers a profile of described relevant aspects of the phenomena of interest.

3.2 Research Approach

The researcher not only selects a qualitative, quantitative, or mixed methods study to conduct, but also decides on a type of study within these three choices. Research designs are types of inquiry within qualitative, quantitative, and mixed methods approaches that provide specific direction for procedures in a research design (Anol, 2012).

To achieve the aforementioned objectives, the study adopted descriptive research and explanatory or analytical research approaches, where it can be use of a questionnaire provided predominantly descriptive and qualified data with inferential statistics method, It is the study involving analysis of data and information that are descriptive in nature and qualified (Sekaran, 2003). The only way in which the qualitative data analysis can make a significant contribution is by utilizing its theoretical resources in the deep analysis of small bodies of publicly shareable data. It is therefore, for this thesis work, the quantitative method will be used because correlation requires quantitative data. Questionnaire and document review were applied in data collection.A survey research design was used because of information was already there (maintenance strategy is already there in Asku Plc plant located in Oromia special zone Burayu) but need to systematically describe its relation with plant performance.

3.3 Population and Sampling Design

3.3.1 Population

There is no perfect homogeneity among any population. System random sampling techniques were used from total population of all departments representing company by their practical exposure and experience to the plant and equipment maintenance activities of the plant. Thus, purposive sampling technique which is judgmental, selective or subjective sampling was used. It is a form of non-probability sampling in which researchers rely on their own judgment when choosing members of the population to participate in their study. It focuses on all departments of Asku plc such as: technical, production, quality, Warehouse and supply managements, Managers, team leaders (heads), shift leaders, supervisors, maintenance and production planners, senior technicians, technical expats, and are from all six production lines Asku plc is currently operating. Warehouse and HR admin was purposively ignored because of both departments totally not part of any maintenance operation.

Table 3. 1: Target Population which was used as a sample size.

Plant sections /Departments	Employee numbers	Purposely Selected	Remark
Technic and Engineering (maintenance team function)	66	30	100% as per criteria
Production	353	22	With criteria and only those with related field of study and involvement
Quality	20	13	With criteria and only those who are aware of subject matter and involvement.
HR and admin	88	0	Excluded because not related with this operations
Warehouse	81	0	Excluded because not related with this operations
Management (supervisors and above)	60	41	Criteria and only those who are aware of subject matter and involvement
Total Employee	**668**	**106**	

Source: Asku HR office of records

Firstly, of the total of 668 permanent employees of Asku Plc, 30 are technic and engineering department, 22 are production, 13 are quality and management positions' are 41 who are participating in maintenance activities, who know operations and leading were targeted population. This was because of the assumption that employees with college diploma (graduates from TVET Schools with level-V, and served company above one-year have better understanding than other discipline) and they are front line in executing maintenance activities of equipment's and plants who have better understanding about maintenance strategy adopted easily. Secondly; others from top management who were directly involved in operation of the plant like: operations officer, director, consultants, expats and others were involved as management team. Thus, total target population sample of **106** were used for the research.

3.3.2 Sample Design

A simple random sampling method was used to select respondents for the study from purposively selected target population. Simple random sampling ensures that each member of the population has an equal chance of being selected. A sample of 106 employees was derived. The determination of the sample was done using Cochran's (1977) formula. In Cochran's formula, the alpha level is incorporated into the formula by utilizing the t-value for the alpha level selected (for example, t-value for alpha level of 0.05 is 1.96 for sample size above 100). For categorical data, 5% margin of error is acceptable (Krejcie & Morgan 1970). Cochran's sample size formula for categorical data is:

n_0= [(t2*p*q)/d2]

$$n = \left\{ \frac{1.96^2 (0.5)(0.5)}{(0.05^2)} \right\} = 384$$

Where:

n = the desired sample size

t2 = value of selected alpha level of .025 in each tail =1.96 (the level of 0.05 indicates the level of risk the researcher is willing to take. True margin of error may exceed the margin of acceptable margin of error.

(p)(q) = estimate of variance = 0.25 (p-Maximum possible proportion (.5) * 1- maximum possible proportion (0.5) produces maximum possible sample size), d= acceptable margin of error for proportion being estimated = .05 (the error the researcher willing to accept)

Therefore, for a population of 106, the required sample is calculated as follows:

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

Where, n is the sample size, N is the population size and n is the target sample size.

Then calculated as:

n=384/ [1+ (384-1)/106] = **83**

3.4 Type of Data to be Collected and Methods

Data collection according to Yin (2002) is the first step taken when planning and implementing a case study because when collected data is incomplete, the researcher is often face with difficulties in analyzing the data, which can lead to the quality of the intended research been poor.

There are several ways of gathering data in carrying out a research work. These data are collected based on the data type namely primary and secondary source. According to Yin (2003), there exist mainly six sources of evidence that are commonly used in data collection process. These processes include documents, archival records, interviews, direct observation, participant observations and physical artifacts (Yin, 2003). The researcher used both primary and secondary data collection methods as source of information.

a. Primary data collection method: - the researcher prepared structured questionnaire as primary data collection method.
b. Additional data used from (e.g. books/journals etc.) called secondary data. Collection methods of those data included published books, articles in journals, articles on the internet, related other researches, brochures, monthly, quarterly and annual company reports, web sites, and the likes were used.

3.5 Data Gathering Instrument

Mainly for this study data gathering instruments were questionnaire and observation guide. Questionnaires' content were developed by the researcher from literatures based on variables which the researcher tried to incorporate in this study and the rest were adopted from other researchers.

The questions were designed in a way that all targeted technical and related staffs were able to understand to avoid misunderstanding and uncertainties on the questions by the respondents. This questionnaire consisted of three parts which are; general information of respondents, four maintenance strategies' namely break down or corrective maintenance, preventive maintenance, predictive maintenance and proactive maintenance related questioners were incorporated under each strategies. On the other side variables like cost of maintenance, factory time efficiency, production in bottles per year, and equipment availability related questioners under each variables were incorporated. Open end questions were also included. Less frequently = 1, Moderate frequently = 2, Frequently = 3, Very frequently = 4, and Most frequently = 5 level of frequency to each particular cases which magnified respondents to indicate level of frequency with the statement provided. The researcher decided to use these tools because; questionnaires were important in gathering basic data from large number of respondent within shortest possible time.

The questionnaires were prepared to address respondent's demographic profile, educational background, department or section of the plant which the respond is working in Asku Plc.

3.6 Pilot Testing

Pilot testing is a small scale preliminary study conducted to evaluate feasibility. In the way that to reduce the possibility of getting the answer wrong, attention need to be paid to two particular issues: reliability and validity (Saunders, 2003).

3.6.1 Validity

Validity defined as the extent to which data collection method or methods accurately measure what they intended to measure (Saunders 2003). Numbers of different steps were taken to ensure the validity of the study:

- It is believed that collected data from all targeted group were from reliable sources.
- Questions were made based on literature review and frame of reference to ensure the validity of the result;

3.6.2 Reliability

According to Saunders, (2003) reliability refers to the degree to which data collection method or methods will yield consistent findings (J. Briony, 2006). SPSS software offers “Reliability Analysis Statistics”: among the models of reliability, Alpha (Cronbach) was used in this study.
In conclusion the real difference between reliability and validity is mostly a matter of definition. Reliability estimates the consistency/uniformity/ of your measurement, or more simply the degree to which an instrument measures the same way each time it is used in under the same conditions with the same subjects. Validity, on the other hand, involves the degree to which you are measuring what you are supposed to, more simply, the accuracy of your measurement. It is my belief that validity is more important than reliability because if an instrument does not accurately measure what it is supposed to, there is no reason to use it even if it measures consistently (reliably).

It is always desirable to pilot-test the data collection instruments before they are finally used for the study purposes at least using a convenience sample (Kothari, 2004). Such pre-testing may uncover ambiguity, lack of clarity or biases in question wording which should be eliminated before administering to the intended sample eventually to get high response rate (Bhattacherjee, 2012). To assure this rule, the researcher has distributed 10 questionnaires for conveniently selected respondents. Sekaran (2003) believed that pilot testing involves the use of a small number of respondents to test the appropriateness and comprehensiveness of questions. Thus, in the pilot-test, pilot respondents were asked to comment on substance of questions against objectives of the study, length of the instrument, format, wording, item redundancy and word sequencing. Among 10 pilot-testing questionnaires, 8 of them (80%) were returned with relevant comments. Thus, based on which the questionnaire was significantly revised by the researcher on the aspects of wording and content of items. Once the revision was completed, it was distributed to the intended respondent for final data collection.

According to Sekaran (2003), reliabilities less than 0.6 are considered to be poor, those in the 0.7 range to be acceptable and those over 0.8 are good. The reliability coefficient closer to 1 is better. Therefore, Cronbach's alpha coefficient of the pilot study was calculated as 0.772 and for the final survey it is 0.698 overall. The scale consistency of the independent variables-are describes below the table 3.2

Table 3.2: Cronbach's Alpha coefficient for each section of Questionnaires

A	Independent variables	No. Items	Alpha Value	Condition
I	**Maintenance Strategies (MS)**			
1	Breakdown Maintenance		.771	Accepted
2	Preventive Maintenance		.664	Accepted
3	Predictive Maintenance		.656	Accepted
4	Proactive Maintenance		.779	Accepted
B	**Dependent variable**			
	Factory Performance Indicators (FPI)		**.698**	
1	Cost of Maintenance		.659	Accepted
2	Factory Time Efficiency		.673	Accepted
3	Equipment Availability		.689	Accepted
4	Production in Bottles Per Year		.770	Accepted

Source: Own Survey (2019)

3.7 Model Specification

The model is chosen to be used in this study owing to its suitability to analyze the causal relationship between dependent and independent variables. The model can be specified as:

Model (1) $y = \beta 0 + \beta 1x1 + \beta 2x2 + \beta 12x12 + \beta 11\ x21 + \beta 22\ x22 + \ldots\ldots\ldots$second order linear model. The multiple linear regression models have two orders. However, because of its simplicity and suitability with the empirical data that was collected, the study was adopted to use the second order model.

Where:

Y = the dependent variable

β0= the constant term/intercept

x1 x2…xk = the independent variables

β1 β2…. βk = the slope coefficient of continuous variable

e= Random error/ residual term.

3.7.1 Correlation (r)

Correlation (r) is used to describe the strength and direction of relationship between two variables. Since all variables are measured as an interval level, Pearson product moment correlation was used. Correlation "r" output always lies between -1.0 and +1.0 and if "r" is positive, there exists a positive relationship between the variables. If it's negative, the relationship between the variables is negative. While computing a correlation, the significance level shall be set at 99 % and 95% with alpha value of 0.01 and 0.05 or a chance of occurrence of odd correlation is 5 out of 100 observations. Correlation is another way of assessing the relationship between variables. To be more precise, it measures the extent of correspondence between the ordering of two random variables. A scatter diagram is a fantastic help when trying to describe the type of relationship existing between two variables.

We can categorize the type of correlation by considering as one variable **increases** what happens to the other variable:

- Positive correlation –when the other variable has a tendency to also increase;
- Negative correlation – when the other variable has a tendency to decrease;
- No correlation – when the other variable does not tend to either increase or decrease.

3.7.2 Multiple Regression Analysis

Multiple Regression Analysis is a major statistical tool for predicting the unknown value of a variable from the known value of variables. Multiple linear regression models are reasonably the most important and extensively used multivariate statistical techniques in most relationship studies that involve ratio/interval variables. This model uses when there is two or more independent variables to predict the value of one dependent variable. The Model for this study was developed using four independent factors or predictors which have influences on the effect of plant and equipment maintenance strategies on factory performance, (Douglas Montgomery et al.., 2012).

$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \varepsilon$

Where Y is the dependent variable, β0 is the constant term/intercept, x1, x2,…x4 are the independent variables, β1, β2…. β 4 are the slope coefficient of continuous variable and random error/ residual term.

3.8 Data Presentation and Analysis Technique

For the goodness of our measurement instruments like: validity and reliability are sets of logical tests that can be used in judging the quality of the result of a research. Criteria like data dependability, consistency and sincerity are mainly used in making the judgments. Victor (2006), enumerate that researches were evaluated against the above-mentioned criteria so as to address the intended audience for the research. Several topics (related to equipment and plant maintenance strategies and factory performance) were conceptualized to formulate the questionnaire. The raw data collected was analyzed using an Ordinal scale: Likert–scale weighted average and conclusions were drawn. The collected data was cleaned, entered and analyzed using IBM SPSS® version 20 for Windows®. Descriptive statistics, and correlation analysis were applied to examine the relationship of plant and equipment maintenance strategies and factory performance. Spearman's rank correlation was used to test whether there is an association between maintenance strategies and performance of the plant. Correlation test, multiple regressions, F-test using SPSS version 20 Software. The data was presented and analyzed in a way it is resulted with the most important information that can answer basic research questions in the best level, ensure objectives of the study and also show future implications of the study.

3.9 Ethical Considerations

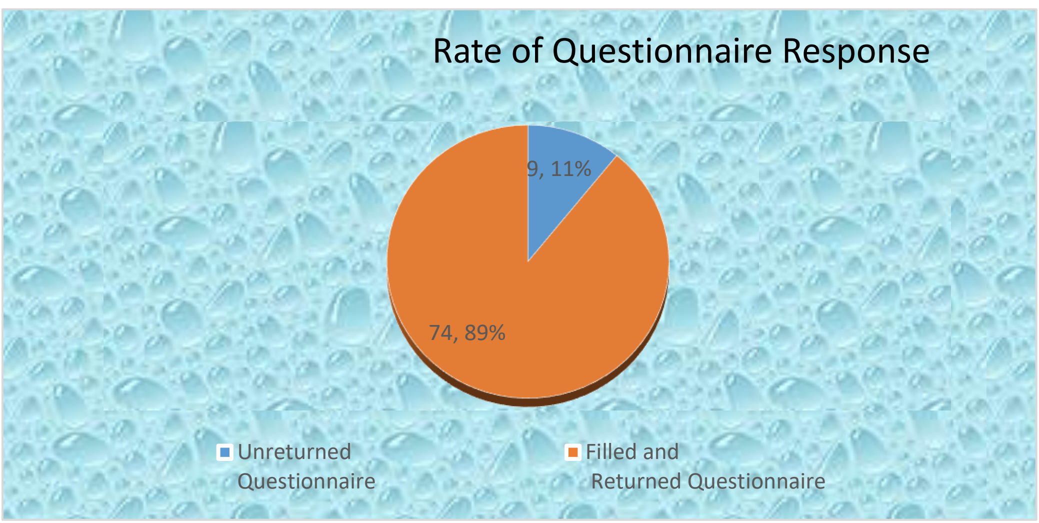
In order to follow the ethical and legal standards of scientific investigation, the study was conducted after approval of saint Marry University School of Graduate Studies review board, Asku Plc's department of human resource, training and development review and approval. Questionnaires were distributed to staffs selected. The purpose of having proper data on the questionnaire was clearly stated. In the study process the name of employees were coded to keep the confidentiality of employees. Conclusions and recommendations reached on were not biased and purely based on the data collected and the feedbacks received from the respondents.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

As indicated in the preceding chapters, this research study attempted to evaluate the effect of plant and equipment maintenance strategies on factory performance of Asku Plc.; a beverage bottling company. A total of 83 questionnaires were distributed to employees and (n = 74) completed and submitted which is an overall response rate of (89.00 %), it was considered robust by Nunnelly (1978).This chapter deals with the discussion and analysis of the findings from collected data by using relative statistical techniques which is mentioned in chapter three. This chapter analyze data collected addressed the research question raised in the first chapter and test the relationship of variables formulated during literatures review in chapter two .The first section of this particular chapter deals about respondents' demographic characteristics and followed by discussion of main part of the chapter which is data analysis part.

Fig 6: Rate of Respondents



Source: Own Survey (2019)

This response rate was representative and satisfactory enough to draw conclusions for the research. According to Mugenda and Mugenda (1999), a 50% response rate is adequate for reporting and analyzing the results; a response rate of 70% and above is said to be excellent in the case for this research.

1.1. Demographic Characteristics of the Respondents’

This section provides a summary of the demographic characteristics i.e. service year of respondent, educational level and current position in category of department.

Table 4.1 Service year (1-5) category of respondents with in departments

Service Year	Educational Back Ground	Measurements	Department of Respondents				Total
			Technical Maintenance	Technical Management	Production Management	Quality	
1-5 years	Diploma	**Count**	**5**	**6**	**0**	**0**	**11**
		% within Educational back ground of the respondents	45.5%	54.5%	0.0%	0.0%	100.0%
		% of Total	8.2%	9.8%	0.0%	0.0%	18.0%
	First Degree	**Count**	**4**	**18**	**15**	**7**	**44**
		% within Educational back ground of the respondents	9.1%	40.9%	34.1%	15.9%	100.0%
		% of Total	6.6%	29.5%	24.6%	11.5%	72.1%
	Second degree	**Count**	**0**	**0**	**3**	**3**	**6**
		% within Educational back ground of the respondents	0.0%	0.0%	50.0%	50.0%	100.0%
		% of Total	0.0%	0.0%	4.9%	4.9%	9.8%
	Total	**Count**	**9**	**24**	**18**	**10**	**61**
		% within Educational back ground of the respondents	14.8%	39.3%	29.5%	16.4%	100.0%
		% of Total	14.8%	39.3%	29.5%	16.4%	100.0%

Source: Own Survey (2019)

As far as service years of respondents is concerned within the range of 1-5 years, of total 61 respondents, 11 (18%), 44 (72.1%) and 6 (9.8%) are diploma, first degree and second degree holders, respectively. Among young respondents participated, 24 (39.3%) are of technical management section of which 18 (29.5%) are first degree holders.

Table 4.2 Service year (5-10) category of respondents with in departments

Service Year	Educational Back Ground	Measurements	Department of Respondents				Total
			Technical Maintenance	Technical Management	Production Management	Quality	
5-10 years	Diploma	**Count**	**8**		**1**		**9**
		% within Educational back ground of the respondents	88.9%		11.1%		100.0%
		% of Total	88.9%		11.1%		100.0%
	Total	**Count**	**8**		**1**		**9**
		% within Educational back ground of the respondents	88.9%		11.1%		100.0%
		% of Total	88.9%		11.1%		100.0%

Source: Own Survey (2019)

From table 4.2 it is observed that total of 9 respondents lie in service years of 5-10 of which 8 (88.9%) are technical maintenance and 1 (11.1) is production section.

Table 4.3 Service year (>10) category of respondents with in departments

Service Year	Educational Back Ground	Measurements	Department of Respondents				Total
			Technical Maintenance	Technical Management	Production Management	Quality	
>10 years	Diploma	**Count**	**1**	**0**	**1**		**2**
		% within Educational back ground of the respondents	50.0%	0.0%	50.0%		100.0%
		% of Total	25.0%	0.0%	25.0%		50.0%
	First Degree	**Count**	**0**	**1**	**1**		**2**
		% within Educational back ground of the respondents	0.0%	50.0%	50.0%		100.0%
		% of Total	0.0%	25.0%	25.0%		50.0%
	Total	**Count**	**1**	**1**	**2**		**4**
		% within Educational back ground of the respondents	25.0%	25.0%	50.0%		100.0%
		% of Total	25.0%	25.0%	50.0%		100.0%

Source: Own Survey (2019)

Table 4.3 shows there was no second degree holder among respondents with service year above 10 and also there was no respondent from quality department with in same service year. It is 2 diplomas and 2 degree holders only from three of the remaining departments.

Table 4.4 Summary of Demographic Characteristics of Respondents

Service Year	Educational Back Ground	Measurements	Department of Respondents: Technical Maintenance	Technical Management	Production Management	Quality	Total
Total (all Service Years)	Diploma	**Count**	**14**	**6**	**2**	**0**	**22**
		% within Educational back ground of the respondents	63.6%	27.3%	9.1%	0.0%	100.0%
		% of Total	18.9%	8.1%	2.7%	0.0%	29.7%
	First Degree	**Count**	**4**	**19**	**16**	**7**	**46**
		% within Educational back ground of the respondents	8.7%	41.3%	34.8%	15.2%	100.0%
		% of Total	5.4%	25.7%	21.6%	9.5%	62.2%
	Second degree	**Count**	**0**	**0**	**3**	**3**	**6**
		% within Educational back ground of the respondents	0.0%	0.0%	50.0%	50.0%	100.0%
		% of Total	0.0%	0.0%	4.1%	4.1%	8.1%
	Total	**Count**	**18**	**25**	**21**	**10**	**74**
		% within Educational back ground of the respondents	24.3%	33.8%	28.4%	13.5%	100.0%
		% of Total	24.3%	33.8%	28.4%	13.5%	100.0%

Source: Own Survey (2019)

From Tables 4.1, 4.2 and 4.3 above it is observed that service years of respondents with 1-5 years, 5-10 years and above 10 years in an organization from total population of 74 respondents are 61 (82.4%), 9 (12.2%) and 4 (5.4%) respectively. Among respondents the highest educational level lie on first degree, of total of 46 which is 62.2 %. 22 (29.7%) are diploma level graduates, and 6 (8.1%) are second degree holders.

The highest department by educational level from diploma level is technic maintenance team with 14 out of 22 which is 63.6% and both technical management and production management each contribute 8 with first degree which accounts 36.4% cumulatively. Total of 6 respondents with 3 each are with second degree which accounts 8.1% of total respondents and there was no second degree holders among both departments of technic maintenance and technic management.

Out of all 74 respondents, 18 (24.3%), 25 (33.8%), 21 (28.4%), and 10 (13.5%) are technical maintenance, technical management, production management and quality department, respectively.

4.2 Analysis of Data and Presentation

4.2.1 Descriptive Analysis

A Likert scale is a type of rating scale used to measure attitudes or opinions. With this scale, respondents are asked to rate items on a level of agreement on frequency. This description analysis measuring instrument is used to calculate plant and equipment maintenance strategies ;Breakdown, Corrective Maintenance (BCM), Preventive Maintenance (PM), Predictive Maintenance (PDM), and Proactive Maintenance (PRM) undertaking in the company and affected variables like Cost of maintenance (COM), Factory time efficiency (FTE), Equipment availability (EqA), Production in bottles per Year (PBPY) are scaled 1 to 5 by designating 1= less frequently, 2=moderate frequently, 3= frequently, 4= very frequently and 5=most frequently. Accordingly a factor takes its average for the questions under it with no decimal point. Despite the fact that for summarizing the narrative out comes, the researcher used criterion-referenced definitions for rating scales to describe the collected data. Thus, the final report of the relevant demographic variables was produced through central tendency measurements (frequency and frequency distribution, valid and cumulative percentage and comparison of mean). The data then presented in form of figures, tables, graphs and charts to present the result with the help of SPSS.

Table 4.5: Criterion – referenced scale definitions

Mean rating	Respondents level of agreement	Description of respond agreement level
1.00 - 1.49	Less Frequently (LF)	Very low (VL)
1.50 - 2.49	Moderate Frequently (MF)	Low (L)
2.50 - 3.49	Frequently (F)	Medium (M)
3.50 - 4.49	Very Frequently (VF)	High (H)
4.50 - 5.00	Most Frequently (MF)	Very high (VH)

Source: MacEachron (1982)

Here noted as "3" means “neither agree nor disagree, while value “4” means “agree”. Hence, if value 3 is recorded as any of the subsequent measurement, it means that level is neither high nor low, or in other words it is in “average or medium level”. If a value of (4) is obtained , it means s “high” level .similarly value one(1) and five(5) mean “very low” level and “very high” level respectively while value two (2) mean “low” level . Based on the above table the researcher discussed on the findings of the descriptive statistics of effect of plant and equipment strategies on factory performance based on referenced scale.

4.2.2 Breakdown, Corrective Maintenance

The main reason of this research on this particular maintenance strategy was to analyze the maintenance activity which is the required to repair, replacement, or restore action performed on a machine or a facility after the occurrence of a failure in order to bring the machine or facility to at least its minimum acceptable condition since it is done on time of occurrences. Six statements with related activities to this particular maintenance strategy were presented for respondents to rate them on a Likert scale. Table 4.6 presents the responses in each statement and the average reaction of respondents in all of the statements. The average result was found by computing the responses in each statement.

Table 4.6. Responses of Breakdown, Corrective Maintenance

Items		Less Frequently	Moderate Frequently	Frequently	Very Frequently	Most Frequently	Mean	Std. Dev.	N
The failed item is restored to its operational state with in a given time.	N	9.0	7.0	27.0	18.0	13.0	3.26	1.217	74.0
	%	12.2	9.5	36.5	24.3	17.6			100.0
The maintenance department follows a standardized servicing procedure.	N	24.0	18.0	16.0	8.0	8.0	2.43	1.335	74.0
	%	32.4	24.3	21.6	10.8	10.8			100.0
The equipment is used as per the manufacturer’s guideline.	N	17.0	16.0	25.0	10.0	6.0	2.62	1.213	74.0
	%	23.0	21.6	33.8	13.5	8.1			100.0
Complete disassembly, examination of all components, repair and replacement of worn/unserviceable parts as per original specifications and manufacturing tolerances is followed.	N	22.0	7.0	20.0	17.0	8.0	2.76	1.383	74.0
	%	29.7	9.5	27.0	23.0	10.8			100.0
Overhauling of equipment as per maintenance serviceability standards, using the “inspect and repair only as appropriate” approach is used.	N	24.0	15.0	18.0	12.0	5.0	2.45	1.284	74.0
	%	32.4	20.3	24.3	16.2	6.8			100.0
Emergency case maintenance activities are considered in maintenance plan.	N	19.0	6.0	17.0	23.0	9.0	2.96	1.389	74.0
	%	25.7	8.1	23.0	31.1	12.2			100.0

Source: Own Survey (2019)

From the result above, it was observed that the frequently carried out breakdown or corrective maintenance task and its weighted Likert score was the failed item is restored to its operational state within a given time (3.26) where 36.5% of respondents responded “frequently” for re storing the failed item back to operation within the given time. This implies the maintenance team will maintain the failed equipment on average within given time. There is an indication of times when there is extended time taken to re store back failed item, while the “moderate frequently” carried out corrective maintenance task was the maintenance team follows a standardized servicing procedure with a weighted Likert score of 2.43. 32.4% of respondents replied the frequency of using standard servicing procedure by maintenance crew during maintenance as “less frequently”. From this we can understand that, in maintenance operation where standard procedures of servicing for a particular equipment is not followed maintenance will not be effective and knowledge management (where technicians learn from each other) too. 24.0% of respondents with mean score of 2.45 agreed that one of the important parameter of corrective maintenance activities called “overhauling of equipment” as per maintenance serviceability standards, using the “inspect and repair only as appropriate” approach is used less frequently. The maintenance team is not organized in a way that serviceability standards should be followed. As far as considering activities in maintenance plan for breakdown or corrective maintenance plan 31.1% of respondents with average score of 2.96 responded as “very frequently” in incorporating emergency case maintenance activities in maintenance plan. This shows from planning side emergency schedules are incorporated weather done or not in the daily maintenance plan. This is because of the trend that machines are failing day to day unexpectedly and because of this reason of total daily operations time emergency rapier or replace times are budgeted for emergency cases and this response particularly shows break down or corrective maintenance for repetitive and or unexpected failures is dominant and company has burden in this regard.

4.2.3 Preventive Maintenance

The main reason of this research in similar fashion for this particular maintenance strategy is to analyze the maintenance activity the plant operation is going on mainly as this way of maintenance is doing a set of activities that are performed on plant equipment, machinery, and systems before the occurrence of a failure in order to protect them and to prevent or eliminate any degradation in their operating conditions. Five powerful statements in relation with this maintenance strategy were presented for respondents to rate them on a Likert scale. Table 4.7 presents the responses in each statement and the average reaction of respondents. The average result was found by computing the responses in each statement.

Table 4.7. Responses of Preventive Maintenance

Items		Less Frequently	Moderate Frequently	Frequently	Very Frequently	Most Frequently	Mean	Std. Dev.	N
Maintaining equipment in operation.	N	9.0	17.0	25.0	17.0	6.0	2.92	1.132	74.0
	%	12.2	23.0	33.8	23.0	8.1			100.0
Carrying out equipment overhauls at intervals.	N	18.0	19.0	21.0	10.0	6.0	2.55	1.229	74.0
	%	24.3	25.7	28.4	13.5	8.1			100.0
The lubrication points/surfaces are identified and serviced as per the specified standard.	N	9.0	26.0	6.0	18.0	15.0	3.05	1.384	74.0
	%	12.2	35.1	8.1	24.3	20.3			100.0
Loose fasteners on equipment are immediately secured if observed.	N	4.0	22.0	18.0	10.0	20.0	3.27	1.296	74.0
	%	5.4	29.7	24.3	13.5	27.0			100.0
Keeping facility/equipment in satisfactory condition through inspection, adjustments, calibration and correction of early-stage deficiencies)	N	26.0	20.0	11.0	11.0	6.0	2.34	1.317	74.0
	%	35.1	27.0	14.9	14.9	8.1			100.0

Source: Own Survey (2019)

As depicted in table 4.7, the most repetitive preventive maintenance activity is immediate securing of loosen fasteners and equipment when observed; by mean score of 3.27 while 18.0%, 10.0% and 20.0% of respondents responded from “frequently”, “very frequently” and “most frequently” to this particular preventive action. This implies technical team has an initiation to correct equipment before getting damaged while observed. This is showing that there is monitoring of equipment and items as a culture while on operations and through observations when found in the wrong way it is fixed back during operations. A 2.34 mean score is the least score related with respondents’ agreement level on keeping equipment in satisfactory condition through inspection, adjustments, calibration and correction of early-stage deficiencies in general. This is a poor maintenance culture where performance of overall factory is affected with less attention of doing or keeping equipment at satisfactory level all the time and majority (35.1%) of respondents to this particular prevention task responded as “less frequently”. This is an indication of feed backs after inspection and when adjustments are done performance level of an item is not usually back to normal operation conditions. This is either due to skill gap or right spare might not be used. Another 35.1% of respondents with mean score of 3.05 (high level of agreement) has responded on pre identified lubrication places or surfaces and doing it as per standard with moderate frequently. This shows maintenance team particularly planning department were not strictly following daily schedules of PM through distributed check lists of lubrication. When the wright manufacturers check lists are followed with pre-defined times and applying places performances of equipment will be kept to the original. When such activities are not practiced there will be an impact on preliminary failures of machines or items where lubrication is not effective as per manufacture's manual or check lists.

4.2.4 Predictive Maintenance

The research questions of predictive maintenance type is designed in a way to answer the strategy of Predictive maintenance as the indication of this strategy defined as a set of activities that detect changes in the physical condition of equipment (signs of failure) in order to carry out the appropriate maintenance work for maximizing the service life of equipment without increasing the risk of failure. Thus, analyzing of the responses from questioners was basing on five statements fits with this maintenance strategy. Accordingly the questioner were presented for respondents to rate them on a Likert scale. Table 4.8 presents the responses in each statement and the average reaction of respondents. The average result was found by computing the responses in each statement.

Form the following predictive maintenance related activities and respondents' output in table, it is observed that awareness to predict initial problem that may cause equipment failure by team doing maintenance is highest with mean score of 2.93. Where 29.7% and 28.38%of respondents responded as "frequently "and "very frequently" respectively. This implies there is no or probably less issue on creating awareness among teams. This is an implication of maintenance teams' weaknesses on sharing information and lack of team spirit and shared jobs. However this question does not show weather the team has implemented this awareness or not. Predictive maintenance related to using test tools or measurements and techniques is the least Likert score of 2.14 of all activities where about 37.8% of respondents said less frequently applied and none of respondents replied in most category. This is an implication of tools like vibrational tests, or other modern electrical tests are not in use to diagnose the machine status. Rather only observations like (sounds, temperature and others) are in sue. This has been proven below as from, technical condition of equipment is not monitored through modern predicting techniques of vibration and electrical condition as respondents of total about 78.4% responded below average in common with mean score of 2.47.

Table 4.8. Responses of Predictive Maintenance

Items		Less Frequently	Moderate Frequently	Frequently	Very Frequently	Most Frequently	Mean	Std. Dev.	N
Equipment and plant condition signs of failure are detected at early stage	N	13	19	19	14	9	2.82	1.275	74.0
	%	17.6	25.7	25.7	18.9	12.2			100.0
Statistical continuous stoppage records are used for predicting failures.	N	25.0	16.0	18.0	15		2.31	1.146	74.0
	%	33.8	21.6	24.3	20.3				100.0
Technical condition of equipment is monitored through modern predicting techniques of vibration and electrical condition are applied.	N	23	21	14	4	12	2.47	1.407	74.0
	%	31.1	28.4	18.9	5.4	16.2			100.0
The maintenance department/team has awareness to predict initial problem that may cause equipment failure.	N	10	16	22	21	5	2.93	1.151	74.0
	%	13.5	21.6	29.7	28.3	6.7			100.0
Plant has hand held test/measurement tools to perform predictive maintenance.	N	28	20	14	12		2.14	1.102	74
	%	37.8	27.0	18.9	16.2				100.0

Source: Own Survey (2019)

25.0% of respondents with a mean score of 2.1 agreed as “less frequently” that the statistical continuous plant and equipment stoppage records are used for predicting failures. This is either due to no proper recording of stoppages or not using data to analyze predicting activities. When the right statistical recordings of the stoppages status of all equipment were not done effectively and analyzed there will be no chance of understanding the failures distribution and attention areas.

4.2.5 Proactive Maintenance

The research questions of proactive maintenance type like others is designed in a way to answer the strategy of Proactive maintenance where its main role is focusing on continuous process of improvement, using feedback and communications to ensure that changes in design/procedures are efficiently made and available to item designers/management, ensuring that nothing affecting maintenance occurs in total isolation, with the ultimate goal of correcting the concerned equipment forever. It performs root-cause failure analysis and predictive analysis to enhance maintenance effectiveness, conducts periodic evaluation of the technical content and performance interval of maintenance tasks (Dhillon, 2006). Therefore, analyzing of the responses from questioners was basing on five statements fits with this maintenance strategy. Accordingly the questioner were presented for respondents to rate them on a Likert scale. Table 4.9 presents the responses in each statement and the average reaction of respondents. The average result was found by computing the responses in each statement.

Table 4.9. Responses of Proactive Maintenance

Items		Less Frequently	Moderate Frequently	Frequently	Very Frequently	Most Frequently	Mean	Std. Dev.	N
Proactively seeking the basic cause's equipment failure and control of repetitive failures.	N	23	14	20	10	7	2.51	1.316	74
	%	31.1	18.9	27.0	13.5	9.5			100.0
Designing of better maintenance methods using maintenance feedback.	N	17	22	11	13	11	2.72	1.390	74
	%	23.0	29.7	14.9	17.6	14.9			100.0
Improving the production processes through maintenance feed back	N	6	26	11	17	14	3.09	1.295	74
	%	8.1	35.1	14.9	23.0	18.9			100.0
Root cause analysis of failures performed up on evaluation always.	N	22	15	16	16	5	2.55	1.305	74
	%	29.7	20.3	21.6	21.6	6.8			100.0
Maintenance team has knowledge and applies about the age of critical items/spare parts	N	27	12	9	20	6	2.54	1.426	74
	%	36.5	16.2	12.2	27.0	8.1			100.0

Source: Own Survey (2019)

From the above table, it is observed that a mean Likert score of 3.09 whose degree of respond agreement level lies in medium category and this is task of improving the production processes through maintenance feedback. This is an implication of efforts on maintenance tasks to improve production processes up on feedback where 35.1% of respondents also responded as "moderate frequently". The lowest scale is 2.51 and this is task of proactive way of maintenance is seeking cause of failures and control of repetitive failures based on the feedback. 31.1% of respondents replied as "less frequently" to this question. This shows causes of failures are not done thoroughly so that same failures are occurring again and again. Doing a root-cause analysis should be done in-depth with teams from all concerned and based on scientific reasons and justifications. Regarding the frequency of doing root cause analysis of failures up on evaluation which is the most important component of giving sustainable solution for certain failure has shown 29.7%, 20.3%, 21.6% of respondents replied as "less frequently", "moderate frequently" and "frequently" respectively with a mean Likert scale of 2.55 which lies in week side of medium. This is an indication of occurrence of same and repetitive failures with in plant. Frequency of doing root causes is less and failure(s) when respective and or affecting performances at large, doing the root cause analysis is the only way that sustainable solution will be given.

4.2.6 Cost of Maintenance

The research question was designed in a way that cost of maintenance is well described, as cost is an absolute term and measures the amount of resources used to produce the product. Maintenance costs are another direct measure of maintenance performance. Maintenance costs are impacted by both maintenance effectiveness and the efficiency with which maintenance is performed.

Thus, analyzing of the responses from questioners focused on three statements which are relevant to this performance indicator was done. Accordingly the questioner were presented for respondents to rate them on a Likert scale. Table 4.10 presents the responses in each statement and the average reaction of respondents. The average result or mean score was used in computing and analyzing the responses.

Table 4.10 Respondents Response on Cost of maintenance

Items		Less Frequently	Moderate Frequently	Frequently	Very Frequently	Most Frequently	Mean	Std. Dev.	N
Plant and equipment maintenance performed mostly leads to frequent machine breakdown and massively depend on labor, materials usage and extended service times	N	13	6	24	19	12	3.15	1.300	74
	%	17.6	8.1	32.4	25.7	16.2			100.0
Uniform maintenance standard for similar installations, equipment and plants.	N	9	16	15	22	12	3.16	1.282	74
	%	12.2	21.6	20.3	29.7	16.2			100.0
Implementing TPM reduces maintenance cost.	N	11	6	17	23	17	3.39	1.333	74
	%	14.9	8.1	23.0	31.1	23.0			100.0

Source: Own Survey (2019)

From the result above, it was observed that the highest Likert score of cost of maintenance is 3.39 which is ensured through implementing TPM. This is g high degree level of agreement and from respondents' side on frequency of exercising 31.1% responded as it is exercised very frequently. Since maintenance cost is the highest cost next to operational budget this particular department should deal with this performance indicator. From the table it shows implementation of TPM which is designed to maximize equipment effectiveness (improving overall efficiency) by establishing a productive-maintenance system covering the entire life of the equipment, spanning all equipment related fields (planning, use, maintenance, etc.) and, with the participation of all employees from top management down to shop-floor workers, to promote productive maintenance through motivation management or voluntary small-group activities (Al-Turki et al., 2014) in doing so cost related with maintenance is reduced. 32.4% of respondents with mean score of 3.15 responded as "frequently" on statement "plant and equipment maintenance performed mostly leads to frequent machine breakdown and massively depend on labor, materials usage and extended service times." This shows, most likely there is extended maintenance time undergoing repetitively with time consuming and more labor with more materials is also needed. This is because of not following right serviceability procedures and not thoroughly doing root cause analysis for sustainable solution. Thus, the company has to asses to reduce the cost associated with maintenance in using large resources. Further an attention to uniform maintenance standard for similar installations, equipment and plants whose mean score of 3.16 and about 29.7% responded as "very frequently". This is due to the nature of all current six bottling lines and their units (blowers, fillers, packers and conveyors) of the company including utilities (water treatment, air) have similar nature of operations equipment and in most cases lines' layout are the same. Thus, operations and level of maintenances with procedures are almost similar.

4.2.7 Factory Time Efficiency

The research question was designed in a way that time efficiency of the factory is in association with the title. Time efficiency is performance of certain activity where it is performed with in predefined boundary of time. Here below, analyzing of the responses was done from questioners focused on three statements which are aligned with this performance indicator. Accordingly the questioner were presented for respondents to rate them on a Likert scale. Table 4.11 presents the responses in each statement and the average reaction of respondents with specific percentiles of response rate. The average result or mean score, and percentiles were used in computing and interpreting the survey result from the responses.

Table 4.11 Respondents' Response on factory Time Efficiency

Items		Less Frequently	Moderate Frequently	Frequently	Very Frequently	Most Frequently	Mean	Std. Dev.	N
The team operates autonomously (running inspection) to achieve the daily objectives.	N	14	10	10	28	12	3.19	1.382	74
	%	18.9	13.5	13.5	37.8	16.2			100.0
Maintenance department and its environment is continually changing with new technologies and standards being introduced in the company which is developed rapidly.	N	19	22	7	23	3	2.58	1.282	74
	%	25.7	29.7	9.5	31.1	4.1			100.0
TPM implementation reduced down times	N	10	8	13	15	28	2.58	1.282	74
	%	13.5	10.8	17.6	20.3	37.8			100.0

Source: Own Survey (2019)

From the above table, it is concluded that the highest score is 3.19 and the lowest are 2.58 equal two statements. The highest mean score was on the effort that team are doing to achieve daily objectives. This is an indication of commitments of team synergy toward achieving a daily targets and within gaps of maintenance, production demands and trying to meet daily targets is there and this activity is done responded as "very frequently" with response rate of 37.8%. This implies team is doing great to achieve daily objectives through responding to failures. 37.8% of respondents with mean score of 2.58 responded that TPM implementation reduced downtimes as "Most frequently" and also the second highest rate of respondents on this particular statement is 20.3% with "very frequently". This is a witness on the effectiveness of TPM which is designed to maximize equipment effectiveness (improving overall efficiency) by establishing a productive-maintenance system. Likewise a mean score of 2.58 goes to adaptation to new technologies, standards goes to technologies and standards which the company is introducing where 31.1% of respondents were agreed for "very frequently". This implies when standards or new way of doings, or machines or systems in operations are introduced team are aware of them.

4.2.8 Production of Bottles per Year

The amount of production produced daily or monthly, quarterly and annually is the total of its time targeted. One of the performance of the plant and expected to play its major role on returns of investment (ROI) is the amount that machines and or labor is producing. Statements or questions if this indicator are designed in a way that all necessary information is related with this indicator. Here below, interpretation of the responses from questioners focused on four statements which are aligned with this performance indicator. Accordingly the questioner were presented for respondents to rate them on a Likert scale. Table 4.12 presents the responses in each statement and the average reaction of respondents with specific percentiles of response rate. The average result or mean score, and percentiles were used in computing and interpreting the survey result from the responses.

From the table 4.12, it is observed that the highest mean score is 3.92 and the lowest is 3.00 equal two statements. The highest mean score was on the statement of how frequently adjustments were made to the equipment during the time when quality of the product is no longer acceptable. To this particular statement 36.5% of all respondents agreed to the level of frequency of "very frequently" and "most frequently" with similar figure of response rate. This shows since production of non-conformity product is not passing to the next operation level adjustments to any kind of parameters or replaces, changes etc. will be done devotedly and from food and beverages regulations the company is doing great on producing quality product to the market.

Table 4.12 Respondents' Response on Production of Bottles per Year

Items		Less Frequently	Moderate Frequently	Frequently	Very Frequently	Most Frequently	Mean	Std. Dev.	N
Plant and equipment maintenance performed affected Hourly/daily lines' output.	N	4	6	18	22	24	3.76	1.156	74
	%	5.4	8.1	24.3	29.7	32.4			100.0
The causes of defects and reworks are removed from the equipment at the first incident.	N	13	6	32	14	9	3.00	1.216	74
	%	17.6	8.1	43.2	18.9	12.2			100.0
Line performance is not consistent as per target.	N	2	14	29	19	10	3.28	1.014	74
	%	2.7	18.9	39.2	25.7	13.5			100.0
Adjustments are made to the equipment when the quality of the product is no longer acceptable.	N	2	9	9	27	27	3.92	1.107	74
	%	2.7	12.2	12.2	36.5	36.5			100.0

Source: Own Survey (2019)

29.7% and 32.4% of respondents responded "very frequently" and "most frequently" respectively with average mean score of 3.76 on the question statement of weather maintenance performed has affected production line out puts or not. It is obvious indication that equipment are maintained in unscheduled way so that lines are idle during the productive times which is scheduled only for operations (production). This emphasis that the time machine has to be ready for production was by far less due to technical reasons and productivity was less accordingly.

4.2.9 Equipment Availability

The research question was designed in a way that machine or equipment availability is pre described, as it is the probability that an item is available for use when required.

Thus, analyzing of the responses from questioners focused on four statements which are relevant to this performance indicator was done. Accordingly the questioner were presented for respondents to rate them on a Likert scale. Table 4.13 presents the responses in each statement and the average reaction of respondents. The average result or mean score was used in computing and analyzing the responses.

Table 4.13 Respondents' Response on Equipment Availability

Items		Less Frequently	Moderate Frequently	Frequently	Very Frequently	Most Frequently	Mean	Std. Dev.	N
Planned and unplanned downtimes significantly affected machine operating times.	N	5		21	29	19	3.77	1.054	74
	%	6.8		28.4	39.2	25.7			100.0
The maintenance department maintains critical spares for all equipment.	N	30	8	9	19	8	2.55	1.500	74
	%	40.5	10.8	12.2	25.7	10.8			100.0
The maintenance department follows CLIT to reduce machine stoppages.	N	10	12	16	26	10	3.19	1.257	74
	%	13.5	16.2	21.6	35.1	13.5			100.0
PM is effectively done by maintenance team as per planned to reduce repetitive stoppage.	N	8	21	19	12	14	3.04	1.287	74
	%	10.8	28.4	25.7	16.2	18.9			100.0

Source: Own Survey (2019)

It is observed from the above table, that planned and unplanned downtimes significantly affected machine operating times where its mean score is 3.77 and 39.2% of respondents responded as "very frequently", which implies both scheduled and unscheduled maintenance types has huge contribution for repetitive stoppages and machine is not available for intended use as per plan.

On the other hand the lowest mean score is 2.55 which is related to availability of critical spares for all equipment, where 40.5% responded critical spare parts are maintained rarely, in which we can interpret that when specific and critical spare parts for machines and equipment are not in inventory, machine performance will be either idle or operates in poor performance because maintenance team may go for modifications or using of substandard parts which has huge impact on availability of equipment. When modifications and other parts other than original manufacture is introduced to failed machine performances will be affected. 13.5% respondents with 3.19 Likert mean score responded "less frequently" on following CLIT (Cleaning, Lubrication, Inspection and Tightening) activities to reduce machine stoppages. This is an indication that this basic maintenance activity used to prolong useful life of equipment is not sustainably done. PM is not effectively done to avoid repetitive stoppages as per respondents from fourth statement whose

Likert mean score is 3.04 with 28.5% rate. To do so right preventive schedules should be followed to increase availability of equipment at an acceptable level.

4.2.10 Summary of Frequency Results of each Variable and Mean Score for Dependent and Independent Variables

Table 4.14 Mean score result summary according to Criterion – referenced scale definitions.

Variables	**BCM**	**PM**	**PDM**	**PRM**	**FP**
Mean score	2.7973	2.8784	2.5676	2.7027	3.3649
Degree of agreement	M	M	M	M	M
Description	Frequently	Frequently	Frequently	Frequently	Frequently

Source: Own Survey (2019)

The survey revealed that the maintenance strategies were found to have meaningful effects on the achievement of factory performance further it is that the aggregated mean of the respondents from, BCM, PM, PDM, PRM and FPI are 2.7973, 2.8784, 2.5676, 2.7027 and, 3.3649, respectively towards "effect of plant and equipment maintenance strategies on factory performance" as per criterion- referred definitions above (Table 4.14). It is observed that PM is the most factor affecting followed by BCM each with Likert score of 2.8784 and 2.7973. The mean of BCM, PM, PDM, PRM and FPI are all frequently (F) which shows medium, this implies that the response for those individual question were scored/responded to agree with frequently. Observing respondent's mean on the dependent variables –Factory performance (FP) and independent variables both are 100.0% lies on medium level which is considered as four of plant and equipment maintenance strategies frequently affect factory performances. Major preventive maintenance activities affected cost of maintenance, machine efficiencies, production rates and machine availability.

Table 4.15 Aggregated Means summary according to Criterion – referenced scale Definitions. (Dependent variables)

	Dependent Variables			
	COM	FTE	PBPY	EqAv
Average of grand means	3.23	2.78	3.49	3.14

Source: Own Survey (2019)

The survey revealed that the most monitored factory performance indicator and its mean weighted Likert score was production of bottles per year (3.49), while the least monitored was factory time efficiency (2.78). Influence of plant and equipment maintenance on the factory performance indicators was recognized by the respondents who acknowledged that four factory performance indicators were frequently affected by the maintenance tasks and were all given a Likert score of above 2.78

4.3 Correlations

Correlation is another way of assessing the relationship between variables. To be more precise, it measures the extent of correspondence between the ordering of two random variables. Pearson's correlation coefficient is used to express the strength of the relationship. This coefficient is generally used when variables are of quantitative nature, that is, ratio or interval scale variables. Pearson's correlation coefficient is denoted by r. Pearson moment correlation Chen (1998) provides the following guidelines on the strength of the relationship of variables. The objective of this research was to examine whether the four of plant and equipment maintenance strategies namely; break down or corrective, preventive, predictive and proactive maintenances, can significantly affect factory performances.

4.3.1 Correlation Analysis between Independent and Dependent Variables

The following correlation tests are made to assertion whether or not a relationship exists between independent variables (break down or corrective maintenance, preventive maintenance, predictive maintenance and proactive maintenance) and dependent variables factory performance. Then, the correlation output of each dependent variable with the independent variables is interpreted based on the following tables.

Table 4.16. Correlations- value of dependent variable with each independent variables

		BCM
FP	Pearson Correlation	.624**
	Sig. (2-tailed)	.000
	N	74
		PM
FP	Pearson Correlation	.701**
	Sig. (2-tailed)	.000
	N	74
		PDM
FP	Pearson Correlation	.504**
	Sig. (2-tailed)	.000
	N	74
		PRM
FP	Pearson Correlation	.693**
	Sig. (2-tailed)	.000
	N	74
**. Correlation is significant at the 0.01 level (2-tailed).		

Source: Own Survey (2019)

From summary of Table 4.16 correlation result between both variables (dependent and independent) are as follows:

Correlation result shows that breakdown or corrective maintenance (BCM) has a strong and significant positive relationship on factory performance (FP) i.e. r=.624**at a significant level of 0.00. Correlation result of preventive maintenance (PM) has a strong and significantly has positive relationship with factory performance (FP) i.e. r=.701**at a significant level of 0.00. Correlation result of predictive maintenance (PDM) has a moderate and positive relationship with factory performance (FP) i.e. r=.504**at a significant level of 0.00. Correlation result of proactive maintenance (PRM) has a strong and significantly has positive relationship with factory performance (FPI) i.e. r=.693**at a significant level of 0.00

Meaning maintenance strategies BCM, PM, PDM and PRM contribute a significant impact on FP, given that the correlation between the four independent variables and dependent variable is strong, strong, moderate and strong respectively. This implies that, if an effort is made towards continual improvements of those maintenance strategies there would be a higher chance of achieving best factory performance. Finally, the degree of association of PM and FP is very high or very strong correlation, this depicts that having effective PM will result in a very ideal performance achieving strategy or tools.

4.3.2 Correlation Matrix with in Independent Variables

The following table shows Correlation Matrix within independent variables

Table 4.17 : Correlation Matrix within independent variables

		BCM	PM	PDM	PRM
BCM	Pearson Correlation	1			
	Sig. (2-tailed)				
PM	Pearson Correlation	.661**	1		
	Sig. (2-tailed)	.000			
PDM	Pearson Correlation	.699**	.693**	1	
	Sig. (2-tailed)	.000	.000		
PRM	Pearson Correlation	.680**	.884**	.618**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	74	74	74	74

****. Correlation is significant at the 0.01 level (2-tailed).**

Source: Own Survey (2019)

From the above inter-correlation matrix table 4.17 association among four independent variables (breakdown or corrective maintenance BCM, preventive maintenance PM, predictive maintenance PDM, proactive maintenance PRM) test result was found all independent variables were positively related to each other ranging from .618** to .884**at the level of significance .000. This is a measure of an association between variables of interest. Correlation coefficients whose magnitude are between 0.5 and 0.7 indicate variables which can be considered moderately correlated. Thus PM and BCM, PDM and BCM, PRM and PM are moderately correlated by coefficients of .661**, .699**, .680** respectively. While PRM and PM are strongly correlated by coefficient of .884**

4.4 Regression Analysis

Before running multiple linear regression analysis, the researcher conducted basic assumption tests for the model. These are normality of the distribution, the linearity of the relationship between the independent and dependent variables and multicollinearity tests. In this research the chosen regression type was multiple regression analysis given that the number of determinant /independent variables to predict the dependent variables are four specifically (Corrective Maintenance (BCM), Preventive Maintenance (PM), Predictive Maintenance (PDM), and Proactive Maintenance (PRM). Each test is explained below.

However before running a multiple regression, there are several assumptions that need to be checked the data meet, in order for its analysis to be reliable and valid, i.e. assumptions of normality of the distribution, independency of residuals, and multicollinearity of variables should

4.4.1 Assumptions of Multiple Regressions

4.4.1.1 Normality Distribution Test (Assumption 1)

Multiple regressions require the independent variables to be normally distributed. Skewness and kurtosis are statistical tools that enable the researcher to check if the data is normally distributed or not. According to Smith and Wells (2006), kurtosis is defined as "property of a distribution that describes the thickness of the tails. The thickness of the tail comes from the number of scores falling at the extremes relative to the Gaussian/normal distribution" Skewness is a measure of symmetry. A distribution or data set is symmetric if it looks the same to the left and right of the center point.

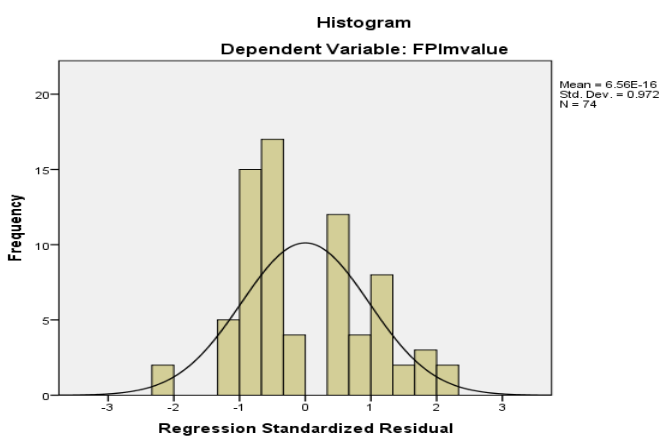
If the skewness and kurtosis test results of the data are within the acceptable range (-1.0 to +1.0), it can be concluded that the data is normally distributed. For this purpose and taste of normal distribution, the kurtosis and skewness results are shown in table 4.18.

Table 4.18: Normality of data distribution

Descriptive Statistics							
Variables	**N**	**Mean**	**Std. Deviation**	**Skewness**		**Kurtosis**	
	Statistic	**Statistic**	**Statistic**	**Statistic**	**Std. Error**	**Statistic**	**Std. Error**
BCM	74	2.7455	.89188	-.192	.279	-1.196	.552
PM	74	2.8270	.83244	-.149	.279	-1.240	.552
PDM	74	2.5351	.79250	.161	.279	-.825	.552
PRM	74	2.6838	.98203	-.218	.279	-1.426	.552
FP	74	3.2548	.63538	-.094	.279	-.280	.552
Valid N (list wise)	74						

Source: Own Survey (2019)

Fig 7: Normality distribution test figure.



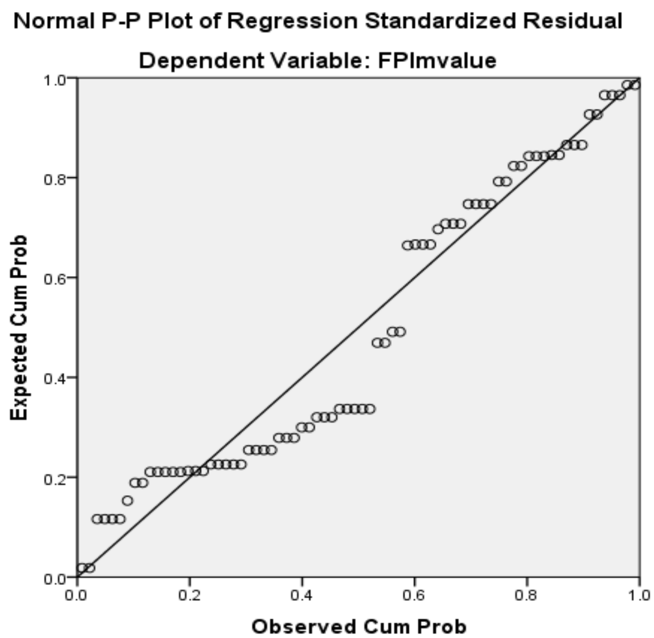
Source: Own Survey (2019)

Skewness result above graph shown the data distribution is symmetric as it looks like same both left and right hand sides. Kurtosis is a measure of weather the data are heavy tailed or light tailed relative to normal distribution. Showed in Table 18 above, all skewness statistics fall in the acceptable range and kurtosis statistics of BCM, PM and PRM are out of range of standard of normality (-1.0 - , +01.0).

4.4.1.2 Linearity of the Relationship Test (Assumption 2)

The second assumption for computing multiple regressions is the test of the linearity of the relationships between dependent and the independent variables. As depicted below, the visual inspections of the scatter plot shows there exists a linear relationship between the dependent variable (FPI) and independents variables figure 8 and 9.

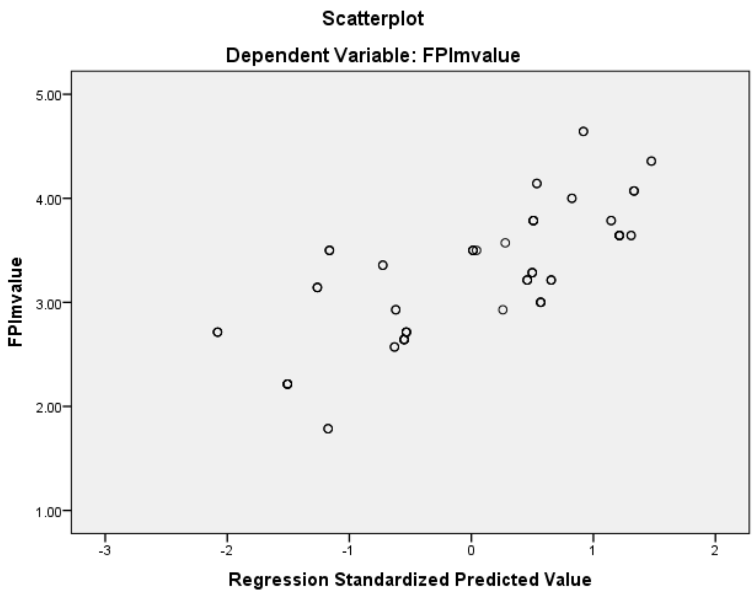
Fig 8: Linear relationship test figure



Source: Own Survey (2019)

In multiple regression analysis there is also assumption of values of the residuals are independent or (uncorrelated). The predication errors or difference between the observed (actual) value of the dependent or the case variable (y) and the predicted value (ŷ) estimated by the regression equation is called the residual (e) and each data point has one residual. i.e. Residual = Observed value - Predicted value. $e = y - \hat{y}$. Both the sum and the mean of the residuals are equal to zero.

Fig 9: Scatter plot for linearity test



Source: Own Survey (2019)

As shown from scatter plot mathematical tools above study correlation between variables. Variables that are positively correlated move in the same direction while variables that are negatively correlated move in the opposite direction.

4.4.1.3 Multicollinearity Test (Assumption 3)

Test for Multicollinearity was checked .and this analysis is fundamentally done for the sake of trying whether multicollinearity is the problem of this research or not before proceeding to the main regression analysis as cited by Belayneh, (2017), to detect any multicollinearity problem or to test the independence of the explanatory variables in regression model the study used a correlation matrix of independent variables. Correlation analysis is used to determine how strongly the scores of two variables are associated or correlated with each other. The problem of multicollinearity usually arises when certain explanatory variables are highly correlated. Multicollinearity refers to the situation in which the independent/predictor variables are highly correlated. When independent variables are multicollinearity, there is “overlap” or sharing of predictive power. This may lead to the paradoxical effect, whereby the regression model fits the data well, but none of the predictor variables has a significant impact in predicting the dependent variable. This is because when the predictor variables are highly correlated, they share essentially the same information. Thus, together, they may explain a great deal of the dependent variables, but may not individually contribute significantly to the model. Meaning, they can be considered as one variable than two separate variables. The existence of multicollinearity can be checked using "Tolerance" and "VIF" values for each predictor variable. Tolerance values less than 0.10 and VIF (variance inflation factor) greater than 10 indicates the existence of multicollinearity (Robert, 2006). As it is observed from the table below, multicollinearity is not an issue.

Table 4.19 Multicollinearity Test Table

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	**VIF**
1	(Constant)		
	BCM	.412	2.427
	PM	.184	5.441
	PDM	.411	2.434
	PRM	.199	5.019

Source: Own Survey (2019)

Tabulated above, for the assumption to meet values of Variance Inflation Factor (VIF) scores must be below 10, and tolerance scores to be above 0.1; which is the case in as shown in table 4.17, the tolerance and VIF of BCM, PM, PDM, and PRM are: .412, .184, .411and.199 respectively. For this reason, this research model fits the requirement and collinearity is not an issue.

Summing up: the three assumptions of multiple regressions are met and the next step is processing the regression analysis to determine the values of the model summary (R and R2), the model fit (ANOVA) and the beta coefficients. With the aid of multiple linear regression analysis, model summary, ANOVA and Beta coefficient were determined and the regression model is developed. In view of that, the qualified effect of independent variables on factory performance is identified.

4.4.2 Model Summary

According to Honnnay (2006), a measure of strength of the computed prediction equation is R-square, sometimes called the coefficient of determination. In the regression model, R-square is the square of the correlation coefficient between the observed and predicated value of dependent variable. If R-square is 1(100%), there exists a perfect linear relationship between the predicators (x i's) and dependent variable (y). An R-square of 0 indicates no linear relationship.

Table 4.20: Model Summary (Test for Independent of Residuals)

Model Summary [b]									
				Std. Error of the Estimate	Change Statistics				
Model	R	R Square	Adjusted R Square		R Square Change	F Change	df1	df2	Sig. F Change
1	.743[a]	.552	.526	.43763	.552	21.219	4	69	.000
a. Predictors: (Constant), PRM, PDM, BCM, PM									
b. Dependent Variable: FPI									

Source: Own Survey (2019)

R is the multiple correlation coefficients which shows the relationship between variables which the study is interested with. From SPSS output above table 4.20, there is a positive relationship of .743 between factory performance (FP) and four independent variables.

R-Square is the proportion of variance in the dependent variable (Factory performance) which can be predicted from the independent variables (breakdown or corrective maintenance BCM, preventive maintenance PM, predictive maintenance PDM, proactive maintenance PRM). Analysis shows a value that indicates 55.2% of the variance in factory performance. This can be predicted from the variables breakdown or corrective maintenance BCM, preventive maintenance PM, predictive maintenance PDM and proactive maintenance PRM. Note that this is an overall measure of the strength of association, and does not reflect the extent to which any particular independent variable is associated with the dependent variable.

R2 = .552 shows that the model accounts for 55.2% of the variation in the factory performance indicators is explained by the linear combination of all the independent variables and the remaining 44.8% of the variation is not explained by these factors in this research.

Adjusted R squared is the coefficient of determination which tells us the variation in the dependent variable due to changes in the independent variable. From the findings in the table 4.9 since adjusted R-square of all the four variables is .526, we can say that 52.6% of the variability in the level of factory performance indicator is accounted for by determinants or factors of performance indicators. In other words, the value of adjusted R squared was .526 and this is an indication that there was a variation of 52.6% of factory performance (FP) due to the independent variables, at 95 percent confidence interval, which means 52.6% of changes in factory performance (FP) could be accounted for by the combination of all the independent variables.

Through cross checking's of all possible assumptions among multiple regression model i.e. normality of data distribution, insufficiency of residuals / error terms / and multicollinearity, multiple regression was carried out.

4.4.3 Model Fit Testing

The regression model overall fit can be examined with the help of ANOVA (analysis of variance) which provides F value. Table 4.10, shows that and F value is 21.219 which indicates F statistics is significant at 0.000 levels and it shows the fitness of the model too. As per the approval standard rule, the significance (P-value) has to be < 0.05 which shows in general the model is fitted for this study. Therefore, it is concluded that there is a relationship between FP and the predictors (PRM, PDM, BCM, and PM).

Table 4.21: ANOVA (Over all Model Fit)

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	16.255	4	4.064	21.219	.000[b]
	Residual	13.215	69	.192		
	Total	29.470	73			
a. Dependent Variable: FPI						
b. Predictors: (Constant), PRM, PDM, BCM, PM						

Source: Own Survey (2019)

The F Value is the mean square regression (16.255) and the mean square residual (13.215), yielding F = 21.219 the p-value associated with this F value is very small (0.000). These values are used to answer the question for the independent variables; breakdown or corrective maintenance BCM, preventive maintenance PM, predictive maintenance PDM, proactive maintenance PRM predict the dependent variable (FP, factory performance). P value was compared to alpha level (typically 0.05) and has to be less than this value. In our case, “Yes” it is less and concluded that; the independent variables reliably predict the dependent variable, and model is fitted. We could say that the group of variables can be used to reliably predict factory performance FP. Had it been P value greater than 0.05, conclusion would be; independent variables did not have any significant relationship with the dependent variable. This is an overall significance test assessing whether the group of independent variables when used together (jointly) reliably predict the dependent variable, and does not address the ability of any of the particular (single) independent variables to predict the dependent variables. Here below next subsection we can see that the possibility of each individual independent variable to predict the dependent variable factory performance FP.

4.4.4 Beta Coefficient

Standardized beta coefficients or proportion of impact are coefficients which explain the relative importance of explanatory variables which compare the strength of the effect of each individual independent variable. These coefficients are obtained from regression analysis after the standardization of all the explanatory variables and these are values for a regression equation. When all variables are standardized to have a mean of zero and a standard deviation of one, because all standardized variables are all expressed in the same units, the magnitudes of the standardized coefficients indicate which variables have the greatest effects on the predicted value. This is not necessarily true for unstandardized coefficients which represents the amount of change in dependent variable.

Table 4.22: Regression Coefficients

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.678	.198		8.456	.000
	BCM	.210	.089	.294	2.343	.022
	PM	.300	.144	.392	2.087	.041
	PDM	-.083	.101	-.103	-.819	.416
	PRM	.135	.117	.209	1.159	.251
a. Dependent Variable: FPI						

Source: Own Survey (2019)

Predicating the success level of FP from the four independent variables or factors, table 4.22 coefficient's table values of standardized beta coefficients state that the degree, extent or strength of how much the independent variables namely; breakdown or corrective maintenance BCM, preventive maintenance PM, predictive maintenance PDM, proactive maintenance PRM predict the dependent variable factory performance FP. This is to mean, the significance tests of the four explanatory variables indicates that only two of its variables; BCM and PM are significant with p-value ($P < 0.05$) for predicting factory performance, FP. The remaining two factors with p-value > 0 .05 ($P > \partial$), PDM and PRM are statistically insignificant to predict dependent variable. This can be interpreted as from the total variance occurred in factory performance (dependent variable), 29.4% is the reflection of breakdown or corrective maintenance, 39.2% is accounted from preventive maintenance.

From the table 4.22, the standardized coefficient of preventive maintenance is the largest value, followed by breakdown or corrective maintenance. The larger the standardized coefficient, the higher is the relative effect of the factors (the greater effects on the predicted value) to FP. In another expression factory performance, FP (Y) is not "statistically" dependent on two insignificant independent variables. Thus, this research could prevail that FP is known to depend on those two independent variables BCM and PM only.

4.4.5 Predicating the Level of Factory Performance Indicators from Four Factors

In the above regression coefficient's, table 4.22 values of standardized beta coefficients state that the two independent variables breakdown or corrective maintenance BCM, and preventive maintenance PM effect, determine or predict the behavior of factory performance FP. From the total variance existed in factory performance (dependent variable), 29.4% is contribution of breakdown or corrective maintenance BCM and 39.2% is of preventive maintenance PM. The variations with significance levels of 0.022 and 0.041 are delivered from effect of plant and equipment maintenance strategies; breakdown or corrective maintenance BCM and preventive maintenance PM, respectively. From this, it is concluded that, in the case of the effect of plant and equipment maintenance strategies on factory performance, preventive maintenance is the major factor affecting of overall factory performance followed by breakdown or corrective maintenance. While the effects of the two plant and equipment maintenance strategies on factory performance were found positive and statistically insignificant. Independent variables xi's is positively related with the dependent variable (y), this implies, the dependent variable FP will increase by percentage amount equal to the beta's value for a unit change in independent variable which is for both for preventive maintenance and breakdown or corrective maintenance which are related positively and their beta value is "statistically" significant, at 0.05 level of significance.

Based the theory and previous empirical research, that the result of both Breakdown or corrective maintenance and preventive maintenance strategies were supported by theory and previous empirical research. This means, the result was consistence with the proposed research design having positive significant effect of equipment and plant maintenance strategies on predicating factory performance table 2.3 Empirical review.

Predictive maintenance: A significant value of 0.416 which is above 0.05 value means this variable was insignificant to this study. As it was described in the theoretical part the idea behind condition based maintenance CBM (type of predictive maintenance) was to assess the condition of technical systems and/or components by monitoring its condition, and perform maintenance only when potential failures are predictable. It depends on continuous or periodic condition monitoring equipment to detect the signs of failure and also another type of this maintenance statistical-based predictive maintenance (SBM) depends on statistical data from the meticulous recording of the stoppages of the in-plant items and components in order to develop models for predicting failures, insignificancy to this variable is due to applicability of this approach is very poor though positive relationship because equipment and plant condition signs of failure at early stage, analyzing statistical records to predict failures, using and application of modern predicting techniques of vibration and electrical condition are activities which an advanced TPM maintenance condition to fulfill and somewhat poor culture in this regard related with the organization which is the researcher's target.

Proactive Maintenance: the result is inconsistence with the proposed research questions and aim that it was believed the characteristics of proactive maintenance include practicing a continuous process of improvement, using feedback and communications to ensure that changes in design/procedures are efficiently made available to item designers/management, with the ultimate goal of correcting the concerned equipment forever, optimizing and tailoring maintenance methods and technologies to each application. Processes like proactively seeking the basic cause's equipment failure, better designing of maintenance methods asper maintenance feedback, improving the production processes through maintenance feedback, and doing of root cause analysis of failures are all related with an approach to a proactive maintenance strategy where in our research case it was not significant which means applicability of these processes approach is very poor though the strategy positively related with factory performance at significant level of 0.251.

4.4.6 Relationship Between the Variables

Standardized beta coefficients are values for the regression equation for predicting the dependent variable from the independent variables. The regression equation is presented in many different ways, By refereeing to this respondent's analysis, the equation for factory performance indicators affected by maintenance strategies of plants and equipment with only significant β coefficients 'of the studied organization is:

Y_{FP} (predicted) = $\beta0 + \beta1x1 + \beta2x2 + \ldots + \beta kxk + E$

$Y_{FP} = \beta0 + \beta1\ BCM + \beta2\ PM + e$

$Y_{FP} = 1.678 + 0.210BCM + 0.300\ PM$

Where;

Y_{FP} (predicted) = Performance level of FP

E = Std. Error of the Estimate (disturbance)

BCM = Breakdown or Corrective Maintenance, PM= Preventive Maintenance.

- From the above estimates, we came to know the relationship between the independent and the dependent variables on the amount of increase/decrease on factory performance that would be predicted by a one unit increase in the predictor.
- The intercept (β0) is the point on the vertical axis where the regression line crosses the Y-axis. The value of (β0) is 1.678 which means the expected value of factory performance is 1.678 when all the two variables assume zero value.
- For the independent variables which are not significant, the coefficients are not significantly affecting factory performance, and we did not incorporate those insignificant variables into the model, but it had been taken into account when interpreting the coefficients.

Table 4.23 Summary of Testing Results from Regression Analysis Coefficients and hypotheses.

	Test	Result	Reason
1	Breakdown Or Corrective Maintenance	Supported	Beta = .294, at .sig. .022
2	Preventive Maintenance	Supported	Beta=.392, at sig. .041
3	Predictive Maintenance	Not Supported	Beta= -.103, at .sig. .416
4	Proactive Maintenance	Not Supported	Beta= .209, at .sig. .251

Source: Own Survey (2019)

Therefore both BCM and PM with significance of .022 and .041respectively and the correlation is significant. Thus, both hypotheses are accepted (H1 and H2).

BCM – The coefficient (parameter estimate) is 0.210, which is an indication of every unit increase in BCM, a 21 % increase in FP is predicted. PM - For every unit increase in PM similarly FP is predicted to be 30 % increases. The higher this variable is, it is PM is more significant variable effect on FP than BCM. That is PM significantly affect FP than others positively.

CHAPTER FIVE

2. SUMMARY, CONCLUSION AND RECOMMENDATION

For industries an important aspect of successful performance is to ensure minimal breakdowns during operation time. The importance of maintenance for manufacturing systems, especially for continues manufacturing systems leads to adopt various maintenance strategies. Since there is no perfect maintenance strategy; selecting a strategy or a suitable combination of strategies has become one of the most important problems for maintenance managers. In addition, each maintenance strategy is applicable for a specific manufacturing system. Therefore, it was the aim of this research to identify plant and equipment maintenance strategies adopted, effect of each strategies on factory performance, factors affecting plant performance and on the way aimed to identify other performance factors of Asku Plc. Here below subsections of this chapter discusses conclusions and recommendations of findings as well as limitations and future implications of the research of which the research had tested all research hypotheses.

2.1. Conclusions

The research results shown that break down or corrective maintenance practices were resulted in restoring back failed items and it was resulted in lesser attention given to servicing procedures. Maintenance planning of this strategy has incorporated emergency case maintenance activities which is carried out as fast as possible in order to bring a failed machine or item to a safe and operationally efficient condition.

Preventive maintenance strategy adoptions for the most repetitive preventive maintenance activities through immediate securing of equipment up on observation has resulted in actions of prevention activities before getting damaged. Because of less efforts and practices of following daily PM schedules; preliminary failures of machines or items where observed mostly and this affected factory performances.

As factory performance indicator a raised cost of maintenance was significant which was associated with frequent machine breakdown and massive labor usages, extra material usages and extended service times. This was because of less attention in the application of systematic preventive maintenance strategies where it is used to keep the cost of maintenance at an acceptable level. Further, it was observed that there was a higher desire to achieve daily objectives of plant output through fast responding to failures in order to increase machine efficiency. The reason why machine efficiencies were not improved by current maintenance practices were very limited practices of TPM and no full implementation of maintenance strategies and philosophies throughout the operation.

Unscheduled maintenances during production of non-conforming product (when quality is no more acceptable) was affecting the production line out puts. It is such clear that, having a well-established and organized maintenance system when considered and further outlined its significance and roles in production performance has made difference.

Because of both scheduled and unscheduled maintenances repetitive stoppages were happening and items or machines were not available for intended use as per plan. Reliable machine performance was a key factor in improving machine availability. Every hour of downtime due to premature failures resulted in costly lost product, Critical spare parts were maintained rarely (not in inventory). Hence, the poor handling of machines' maintenance lead maintenance team to go for modifications or using of substandard parts which was a reason for not keeping equipment in satisfactory condition.

In general the research revealed that the maintenance strategies both preventive and break down or corrective maintenance strategies are adopted by Asku Plc with their significant effect on factory performance by 39.2% and 29.4% each with Likert score of 2.8784 and 2.7973 respectively. For every unit increase in preventive maintenance factory performance is predicted to be 0.300 units. While every unit increase in break down or corrective maintenance, a 0.210 unit increase in factory performance is predicted. The positive correlation between maintenance strategies and factory performance has proven plant and equipment maintenance strategies play a key role in the factory performance.

The survey also revealed cost of maintenance, factory time efficiency, bottles production, and equipment availability were indicators of factory performance where that the most monitored indicator and its mean weighted Likert score was production of bottles per year (3.49), while the least monitored was factory time efficiency (2.78). Effect of plant and equipment maintenance on the factory performance indicators was recognized by the respondents who acknowledged that four factory performance indicators were frequently affected by the maintenance strategies and the two: cost of maintenance and equipment availability were all given a Likert score of 3.23 and 3.14 respectively.

Lack of spare part delivering timely which was indication of poor inventory management, carelessness or lack of commitment at functional level, short comings on job training when new technology or process changes were implemented or introduced and turnover of skilled staffs (leadership), higher reject rates were found to be other factors affect productivity and machine availability which affects overall performance of factory.

4.1 Recommendations

Maintenance must be considered as an organizational policy as one of their strategy to be productive, competitive and the department must be given special emphasis, as it is one of the main areas for productivity improvement. While adapting maintenance strategies attentions to an effective maintenance planning must be given and servicing procedures and standards of each items should be followed. The effective planning which depends on the skills of the planners, the availability of well-developed maintenance database about standard time to repair, a complete repair procedures and the required labor skills, specific tools, parts and equipment should be effectively practiced. Practices of following daily PM schedules, applying statistical data recording of failures for root case analysis to each particular and significant failures and tasks of improving the production processes through maintenance feedback should be implemented and make it as culture in an organization to improve industry performances.

In maintaining cost of maintenance at acceptable limit through adopted maintenance strategies, team must always evaluate and monitor the frequency of items or machines breakdown, excess labor, extra material usages and extended service times all the time. Daily objectives of plant output will be achieved through fast responding to failures and machine efficiency will be increased and the company has to work towards improved productive-maintenance systems to ensure upraised performance.

A modern prevention technique called Total Productive Maintenance (TPM) activities which is involving operators in maintaining their own equipment, independent of the maintenance department must aggressively implemented and practiced by the team so that through strategical implementation of autonomous maintenance program including: daily inspections, lubrication, parts replacement, simple repairs, and abnormality detection and precision checks can be referred as CLIT (cleaning, lubrication, inspection and tightening) useful equipment life can be prolonged and hence performance should be higher through preventing equipment deterioration, restoring equipment to its ideal state, and establishing basic conditions needed to keep equipment well maintained and available. Focusing on this technique of preventive maintenance and its proper management can bring a saving through reducing cost of maintenance which might in turn reduce use of spare parts through repetitive stoppages or keeping machines from unnecessary modifications or using of non-original spares.

When there is no attempt to anticipate maintenance requirements, maintenance planning has to identify and consider scheduling of selected equipment of the plant and use true corrective maintenance strategy so that it is adaptable, sustainable, and continually improving by maintenance team and use as a strategy. To increase the machine availability or decreasing down time the machine operator skill and responsibility must be improved with proper training until he/she cop up all the needful skill.

Through applying right maintenance schedules out puts and efficiencies of all units must be ensured and on the other hand, availability or inventories of critical spare part of components for all critical equipment in the plant and its management, training on maintenance management (leadership), on job trainings for technicians and operators, statistical recordings and analysis of root cause for repetitive and costly failures should be implemented unfailingly by the company.

4.2 Suggestion for Future Research

This research was conducted only on one case company among many similar companies which are emerging all over the country. This kind of research can be done by considering more than one case company to compare the power of the independent variables. Thus, future researchers can rely on reliable operations data of more years for same research title and survey could be on many related industries through statistical analysis. This can lead on the formulation of maintenance strategies which could be adaptable in Ethiopian beverage industries.

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Appendix I: Questionnaire

Section A: General Information

Instruction: Please, put tick mark (√) in the box provided against your choice

1. Educational background:

    Diploma level □, First-degree □, Second degree□, other (specify) ___________________

2. Service year in Asku Plc: Years 1-5□, 5-10□, above 10□

3. Current Position category:

Technic Maintenance Team □ Technical Management,□ Production Management□, Quality Management □Other (specify)________________________________

The target population consisted of 83Senior technicians, Mechanics, Supervisors, Shift Leaders, Technical, Production, Quality heads and Managers who are involved directly and evaluating maintenance activities in manufacturing department.

Section B: Questionnaire

Questionnaire to be filled by Employees of Asku Plc.

Dear Participants:

I am conducting a research on the topic **"The effect of Plant and Equipment Maintenance Strategies on Factory Performance, of Beverage Bottling Company, the case of Asku Plc."**

Dear participants, I kindly request you to fill in the questionnaire and provide relevant information to the best of you to facilitate the study undertakings. The data provided will be treated with strict confidentiality for the purpose of this study only.

Thank you for your time in advance.

	Questions	Likert Scale /frequency/				
		Most frequently = 5	Very frequently = 4	Frequently = 3	Moderate frequently = 2	Less frequently = 1
Break down, corrective Maintenance						
1	The failed item is restored to its operational state with in a given time.					
2	The maintenance department follows a standardized servicing procedure.					
3	The equipment is used as per the manufacturer's guideline.					
4	Complete disassembly, examination of all components, repair and replacement of worn/unserviceable parts as per original specifications and manufacturing tolerances is followed.					
5	Overhauling of equipment as per maintenance serviceability standards, using the "inspect and repair only as appropriate" approach is used.					
6	Emergency case maintenance activities are considered in maintenance plan.					
Preventive maintenance						
1	Maintaining equipment in operation					
2	Carrying out equipment overhauls at intervals.					
3	The lubrication points/surfaces are identified and serviced as per the specified standard.					
4	Loose fasteners on equipment are immediately secured if observed.					
5	Keeping facility/equipment in satisfactory condition through inspection, adjustments, calibration and correction of early-stage deficiencies)					
Predictive maintenance						
1	Equipment and plant condition signs of failure are detected at early stage					

2	Statistical continuous stoppage records are used for predicting failures.					
3	Technical condition of equipment is monitored through modern predicting techniques of vibration and electrical condition are applied.					
4	The maintenance department/team has awareness to predict initial problem that may cause equipment failure.					
5	Plant has hand held test/measurement tools to perform predictive maintenance					
Proactive maintenance						
1	Proactively seeking the basic cause's equipment failure and control of repetitive failures.					
2	Designing of better maintenance methods using maintenance feedback.					
3	Improving the production processes					
4	Root cause analysis of failures performed up on evaluation always.					
5	Maintenance team has knowledge and applies about the age of critical items/spare parts					

Question		**Likert Scale /Effectiveness/**				
		Most effectively = 5	Very effectively = 4	Effectively = 3	Moderate effectively = 2	Less effectively = 1
Cost of Maintenance						
1	Plant and equipment maintenance performed mostly leads to frequent machine breakdown and massively depend on labor, materials usage and extended service times.					
2	Uniform maintenance standard for similar installations, equipment and plants					
3	Implementing TPM reduces maintenance cost.					

Factory Time Efficiency						
1	The team operates autonomously (running inspection) to achieve the daily objectives.					
2	Maintenance department and its environment is continually changing with new technologies and standards being introduced in the company which is developed rapidly					
3	TPM implementation reduced down times.					
Production in bottles per year						
1	Plant and equipment maintenance performed affected Hourly/daily lines' output.					
2	The causes of defects and reworks are removed from the equipment at the first incident.					
3	Line performance is intermittent					
4	Adjustments are made to the equipment when the quality of the product is no longer acceptable.					
Equipment Availability						
1	Planned and unplanned downtimes significantly affected machine operating times.					
2	The maintenance department maintains critical spares for all equipment.					
3	The maintenance department follows CLIT to reduce machine stoppages.					
4	PM is effectively done by maintenance team as per planned to reduce repetitive stoppage.					

II. Open ended questions he qualitative results.

1. What types of basic machine operation skills required for maintenance activities in Asku Plc.?____
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2. What is the best practice Asku Plc implementing effective maintenance strategy's to increase its productivity to budget plan?____
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3. Describe any observable expertise training skills gap which affects maintenance activities of Asku
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4. How do you describe Lack of skilled manpower (machine operator and mechanic team reduce down time and increase machine availabity?
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5. How do you describe substantial Lack of initiation and carelessness among team affects down time and increase machine availability?
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6. How do you describe lack of spare part delivery affect machine down time and increase machine availability?
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