ST.MARY'S UNIVERSITY SCHOOL OF GRADUATE STUDIES

THE RELATIONSHIP BETWEEN MACHINERY MAINTENANCE AND PRODUCTION PERFORMANCE IN THE CASE OF EAST AFRICA BOTTLING SHARE COMPANY

BY

DESTA LEMLEM

(ID: SGS/0073/2008B)

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF MASTER OF BUSINESS ADMINISTRATION OF THE UNIVERSITY OF SAINT MARRY.

ADVISOR: DR. MARU SHETE (PHD)

JANUARY, 2018

ADDIS ABABA, ETHIOPIA

THE RELATIONSHIP BETWEEN MACHINERY MAINTENANCE AND PRODUCTION PERFORMANCE IN THE CASE OF EAST AFRICA BOTTLING SHARE COMPANY

BY

DESTA LEMLEM

A THESIS SUBMITTED TO ST.MARY'S UNIVERSITY, SCHOOL OF GRADUATE STUDIES
IN PARTIAL FULFILLMENT FOR THE REQUIREMENTS OF THE DEGREE OF MASTER OF BUSINESS ADMINISTRATION (GENERAL MANAGEMENT CONCENTRATION)

ST.MARY'S UNIVESITY SCHOOL OF GRADUATE STUDIES

THE RELATIONSHIP BETWEEN MACHINERY MAINTENANCE AND PRODUCTION PERFORMANCE IN THE CASE OF EAST AFRICA SHARE COMPANY

BY

DESTA LEMLEM

APPROVED BY BOARD OF EXAMINERS

______________________________	__________________
Dean Graduate Studies	Signature
______________________	__________________
Advisor	Signature
_______________________	__________________
External Examiner	Signature
_______________________	____________________
Internal Examiner	Signature

DECLARATION

I, the undersigned, declare that this thesis is my original work, prepared under the guidance of Maru Shete (PhD). All sources of materials used for the thesis have been duly acknowledged. I further confirm that the thesis has not been submitted either in part or in full to any other higher learning institution for the purpose of earning any degree.

Desta Lemlem ____________________

Name Signature

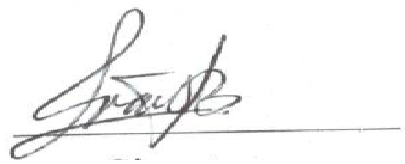
St. Mary's University, Addis Ababa January, 2018

ENDORSEMENT

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

Dr. Maru Shete   signature

Advisor name



St. Mary's University, Addis Ababa   January, 2018

DEDICATION

I dedicate this thesis to my wife Letebrhan Haftay as well as my children, my mother, father, sister, brother, nephews and nieces who supported and encouraged me in my academics work.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank God for his profound gratitude for the strength and courage he has given me to face this academic challenge. I would also like to thank and give my heartfelt appreciation to my advisor Maru Shete (PhD) for his consistent support thorough out the research work. Moreover, I am exceedingly grateful to my wife Letebirhan Haftay and Biruk Solomon and my friends for their constructive suggestions, criticisms and valuable contributions for making this project successful. All their contributions put this work to its rightful perspective.

My undeserved acknowledgement also goes to the coworkers and respondents of East Africa Bottling share company, who were randomly selected for the study for their maximum support and co-operation for making the data available which contributed to the success of my thesis.

Table of Contents

LIST OF ABBREVIATIONS

AM-Autonomous Maintenance

BD-Break down

CBM-Condition Based Monitoring

CMMS-Computerized maintenance management system

CCBA-Coca Cola Beverage Africa

DT-Down time

EABSC-East Africa Bottling Share Company

ETB-Ethiopian Birr (local currency for Ethiopia)

EF-Equipment Failure

EBI-Empty bottle inspection system

FBI-full bottle inspection system

HRs- Hours

KPI-Key performance indicator

ME-Machine efficiency

MC-Maintenance cost

MWI-Maintenance work instruction

OPF-Operational Failure

PM-Planned Maintenance/preventive maintenance

PQ-Production quantities

PLC-Programmable logic controller

RCM- Reliability Centered Maintenance

RGB-Returnable Glass Bottles

SOP-Standard operating procedure

SAP-System application and Products integrated software

SD-Shutdown Maintenance

TPM- Total Productive Maintenance

TPPM-Total Plant Performance Management

VAT-Value added time

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The aim of this study is to investigate the relationship between machinery maintenance and production performance. In addition to this, it describes the challenges of machinery maintenance and the range of maintenance practices performed in achieving production goal to enhance production performance in the case of EAB SC. This study used a descriptive research design and the potential respondents include maintenance managers, maintenance planners, maintenance technicians (Electricians and Mechanics), production operators, production team leaders and top managers who are directly part of the job in both the production and engineering department. The study used a primary data of Questionnaire and interview questions and secondary data collected from a SAP (system application and process software system) to analyze and interpret the relationship between machinery maintenance and production performance as well as the maintenance challenges and practices employed in EABSC. The quantitative data collected was analyzed by the use of descriptive statistics using SPSS while the qualitative data was analyzed using content analysis.

The survey was done in the four production plants of EABSC found in Addis Ababa. Spearman's ranks as correlation coefficients were used to know if there are any relationship between maintenance cost/expenditures, machine efficiency with that of production performance. Findings revealed that there is a negative correlation between maintenance costs with that of production performance. On the other hand, there is a positive correlation between machine efficiencies with that of maintenance cost. Therefore, the conclusion is a huge amounts of maintenance cost not necessarily brings an improvement in sustaining the performance of the equipment but the focus towards maintenance practice such as autonomous maintenance and predictive maintenance brings an improvement on production performances and in turn sustaining company production objectives.

It is recommended that EABSC in particular and CCBA plants in general should monitor and aim at improving the maintenance policies and strategies, maintenance planning and proper execution of maintenance activities, implementing an autonomous maintenance through operators involvement and use of predictive maintenance technologies through training and giving attention to details to PM tasks which improves the efficiency and in turn maximizes the production performance of the factories.

Key words: Maintenance practices, Maintenance cost, production performance and Machine efficiency, East Africa Bottling sh.co, Ethiopia

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Maintenance is defined according to the European standard as 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 a required function.” (EN 13306: 2001). Maintenance is the stamina of any manufacturing organization. Without having the proper maintenance practice and maintenance strategy, an organization asset or equipment cannot sustain its performance and upkeep their health and may depreciate quickly which impacts the productivity and profitability of the organization. As organizations grow, they experience a combination of business complexity and changing organizational roles, coupled with improved power of information technology. These developments are exerting pressure on organizations to act in order to remain competitive (Tsang, 1999). This follows to establish maintenance best practices at company level so as to improve the production performance of the production lines. It is known that attention on the maintenance practices is important to achieve organizational objectives. According to Vavra (2016), it is possible to implement maintenance best practices, and in doing so will help to save time and money while increasing production in the long run. Maintenance practice and strategies are very important component of manufacturing and operation plants. Organizations are often so busy maintaining equipment that efforts to plan and eliminate down time losses. Efforts in reliability engineering should emphasize elimination of failures that require maintenance which is an opportunity to pre-act instead of react. The first and most valuable digit to eliminate or reduce the need for maintenance is maintenance improvement efforts (Mobley, 2004) in order to increase performance of production lines. Thus, maintenance practice and strategies are a set of principles that involves organized series of maintenance philosophies designed to boost performance or efficiency of equipment’s and reduce down times of machineries. According to Mobley (2008), the absence of well-established maintenance policy, lack of adequate maintenance budget, inadequate spares availability, inappropriate technical and operational trainings, lack of technical and operational knowledge, implementing outdated training methods are some of the major problems that most manufacturing organizations are facing during the establishment of maintenance practices and policies. These problems later on lead the manufacturing organizations to lack of sustainable production performances that brings resistances of artisans in taking future assignments, decreasing in productivity, increase in operational error, increased negligence and lack of due attention when fixing maintenance problems.

Maintenance management is the direction and organization of resources in order to control the availability and performance of industrial plant to some specified level (Parida & Kumar, 2006). Maintenance management involves planning, scheduling, organizing, controlling maintenance activities. This involves a mixture of policies and techniques which varies from facility to facility According to Al- Najjar (2000), maintenance strategy depends on several factors, and these are, the goals of maintenance, the nature of facility or equipment to be maintained, work flow patterns and the work environment.

According to Borris (2006), for maintenance practice and systems to be effective and resulted in production improvement, it must be incorporated with a set of maintenance strategies and maintenance performance indicators. Maintenance practices pertaining to provision of productivity, opportunities for growth and development within the organization and management's supervision and guidance are very important for successful maintenance practices implementations.

Simply assessing the maintenance alone is not the key to better production performance of manufacturing organizations. Organizations need to look into the improving the artisan's and operator's technical and operational training with right maintenance knowledge and philosophies. And furthermore, establishing standardized operating procedures for reactive and preventive maintenance plays paramount importance to the performance improvement of production plants. As organizations grow larger, either by adding more shifts or locations, doing things the way they've always been done won't necessarily work anymore.

According to Vavra (2016), deploying maintenance practices takes analysis, planning and skill. Above all, it requires a commitment to move from a reactive to a proactive state of mind. Furthermore, Companies are focusing on establishing proper maintenance programs as a base to build upon their competitive strategy within the market. After all, premium performance of production equipment drives profitability and can transform an organization's operational success.

1.2 Statement of the Problem

There is interdependence between equipment maintenance and production performance. equipment breakdown bring about production disturbances which affect operational performance in product quality, production speed, production cost, plant availability, work conditions, environment, safety (Bellgran and Säfsten, 2010). It is agreed that Maintenance practices influences a production performance through their effect on quality, speed, cost and efficiency. A poor maintenance practices can have some challenges on production performances, unscheduled machine breakdown, machine downtimes and frequent operational errors with in manufacturing plants (Bellgran and Säfsten, 2010).

In this regard, there is no studies made on machinery maintenance practices and its relationship on production in the case of Ethiopia made recently. Some researchers show that they do not give much attention to relationships of the machinery maintenance practices and the maintenance strategy with that of production performances. Rather the studies showed that more attention has been paid to the preparation of documentation and written programs than to the actual problems and less focus was given to the alternative ways of improvement in production volume. Likewise, many of the researchers like Karanja (2009), and Opondo (2011) tried to conduct their research on impacts of maintenance practices and maintenance performance measurement of power and performance measurement practices and maintenance improvement of plants in Kenya. However, none of them have tried to see the relationship between machinery maintenance with production performance by considering the maintenance cost, machine efficiency and the maintenance challenges in a particular plant and have not put improvements methods to enhance production performances.

The aim of this research is to investigate the relationship between machinery maintenance and with the production performance in case of East Africa Bottling share company. The study seeks to determine the challenges influencing production performance, the challenges of maintenance and maintenance practices and relationship of machine maintenance and production performance performed in the four production plants of EABSC.

1.3 Research questions

In order to examine and investigate relationship between machinery maintenance and production performance, the research addresses the following research question:-

I. Is maintenance practice related to production performance?
II. Do maintenance cost relate with production performance?

III. Is machine efficiency related with production performance?

IV. What are the challenges of machinery maintenance practices?

1.4 Objective of the study

The objectives of the research were:

a) to describe the maintenance practices employed in East Africa Bottling Share Company

b) to determine the machine efficiencies of the production plants in East Africa Bottling Share Company and describe its relationship with production performance

c) to determine the relationship between maintenance cost and production volume in East Africa Bottling Share Company.

d) to investigate the challenges of machinery maintenance practices to enhance production performances.

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. (EN 13306: 2001)

Maintenance policy:

A description of the interrelationship between the maintenance echelons, the indenture level and the level of maintenance to be applied for the maintenance on an item. (BS 383811: 1993)

Maintenance Strategy:

The management method used in order to achieve the maintenance objectives.(EN133O6:2001)

Machine Efficiency/Equipment Efficiency:

Equipment efficiency is commonly used to metric when evaluating a manufacturing system. The efficiency is typically maximized by running the equipment at its highest speed, for as long as possible, to increase the product throughput (Mobley, 2008). In another term it is the ratio of value added time into the sum of value adding time plus machine losses).

Production:

Production/operations management is 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. Therefore, it is that part of an organization, which is concerned with the transformation of a range of inputs into the required (products/services) having the requisite quality level (S.Anil Kumar, N.Suresh, 2008).

Performance:

Performance is the level to which a goal is attained. (Alsyouf, 2004)

Maintenance Management:

Administrative, financial, and technical framework for assessing and planning maintenance operations on a scheduled basis (Mobley, 2008).

Maintenance Cost:

A major portion of the operating costs of production plants which is related to maintenance expenditures.

Shutdown Maintenance:

Shut down can be defined as scheduled down period for a plant for scheduled maintenance for an extended period of time. Shutdowns provide unique opportunities to a maintenance department not normally available during standard operation or even during short shutdown periods. A large work is required to schedule into a relatively short period of time. This is a set of preventive maintenance activities that are carried out when the production line is in total stoppage situation.

1.6 Significance of the Study

The research provides Key answers for East Africa Bottling Share companies and other bottling factories in a similar business in identifying the challenges and problems affecting production performance taking the machinery maintenance into consideration. These maintenance practices and challenges when addressed will lead to machine efficiency and improved performance of the plants. The study is also very important to academics and other researchers in that it forms the basis for further research work in machinery maintenance practices for all processing and manufacturing industries and other similar beverage and brewery bottling factories. In addition to this, the study also provides an information to industrial stakeholders in Ethiopia with a framework to develop a maintenance management framework through which they can implement suitable maintenance strategies and policies that will contribute towards improvement of production performance and contribute towards overall business success.

1.7 Scope and Limitation of the study

It was such a difficult job to get all the questionnaires returned in a short period of time. The staffs working in EABS and specially the managers were in a kind of routing management meeting that has influenced on time returning of the questionnaires. Gathering the secondary data and categorizing the reports based on the required need of the study and receiving information from the responsible person was such a time consuming activities to keep the study forward. Moreover, there are some peak seasons for high product demand in CCBA. The equipment may not be allowed to produce equally during rainy and dry season. Thus, the production output of the EABSC may vary from season to season, and because of this the study could not establish the effects of seasonal dynamics on maintenance practice and production outputs. Similarly, the study is limited to EABSC even if it can work for all bottling and brewing companies as there exists the same principle of industrial culture.

1.8 Organization of the thesis

The organization of this thesis is as follows:

Chapter two- introduces the literature review in detail. We first describe the definition of the Maintenance, types of maintenance approaches, maintenance programs and philosophies. PM, RCM and autonomous maintenance. Then we list out all the parameters of the maintenance cost, maintenance efficiency and production performances. The other section in Chapter two is focusing on reviewing other related literatures on the relationship of maintenance cost and production output, and the last show how conceptual frame work is formulated.

Chapter three- provides a brief description on the research design and approach. Following the research design, the sampling techniques, the instruments of data collection, procedures of data collection and the methods of data analysis will be pointed out.

Chapter four-discuss the data analysis, results and discussions of the findings. The characteristics of the respondents will be discussed in relation to the research objectives. The result of the study and the implications of findings will be reported. It will be made a point-to-point analysis of relationships of maintenance cost and production performances. Spearman’s correlation coefficients will be used to examine and compare the variables.

Chapter five- summary of the findings, conclusions and recommendations of the study will be summarized. This chapter gives a conclusion drawn from the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Definition and Concepts of Maintenance

According to Duffuaa (2010), maintenance is defined as the combination of activities by which equipment, assets or a system is kept or restored to a state in which it can perform its designated function. It is an important factor in product or service quality and can be used as a strategy for successful business competition.

Maintenance provides great value to any company when developed, managed, and proper discipline are applied. What is most misunderstood about maintenance is the true objective of the function. The objective of maintenance is to maintain the assets of a company so that they meet the reliability needs at an optimal cost and thus the ultimate goal of maintenance is to provide optimal reliability which meets the business needs of the company (Day, 2015). According to Bloch and Geitner (2005), maintenance and repair of machinery in a manufacturing process plant was defined as upkeep of equipment or as simply "defending machinery against deterioration.

2.2 Types of Maintenance Approaches

Mobley (2004) discusses the various approaches to Maintenance. According to Mobley (2004), there are two types of maintenance management that are typically utilized by industrial and process plants; corrective maintenance and preventive maintenance.

Corrective maintenance is carried out after fault recognition and is intended to put equipment's into a state in which it can perform a required production function. This management approach is, "run until it fails" (Mobley, 2004). The maintenance type is emergency, repair, unscheduled and remedial tasks (Mobley, 2004). Though this method has been a major part of the maintenance operations it is also the most expensive one due to high machine downtime, low production availability, high overtime labor costs and high spare parts inventory cost (Mobley, 2004). Analyses has indicated, according to Mobley (2004), that this corrective approach of maintenance cost in average three times more than the same repair in a preventive approach.

2.3 Types of Maintenance Programs and Maintenance Philosophies

According to Mobley (2004), the Industrial and process plants typically utilize two types of maintenance management philosophies which are called run-to-failure, or preventive maintenance.

2.3.1 Run-to-Failure Management (Reactive Maintenance Breakdown or Run-to-Failure Maintenance)

The logic of run-to-failure management is simple and straightforward. When a machine breaks, fix it. This ‘‘if it ain’t broke, don’t fix it’’ method of maintaining plant machinery has been a major part of plant maintenance operations since the first manufacturing plant was built, and on the surface sounds reasonable (Mobley, 2004, page 2). A plant using run-to-failure management does not spend any money on maintenance until a machine or system fails to operate. Run-to-failure is a reactive management technique that waits for machine or equipment failure before any maintenance action is taken. It is in truth a no-maintenance approach of management. It is also the most expensive method of maintenance management. few plants use a true run-to-failure management philosophy. In almost all instances, plants perform basic preventive tasks (i.e., lubrication, machine adjustments, and other adjustments) even in a run-to-failure environment. However, in this type of management, machines and other plant equipment are not rebuilt nor are any major repairs made until the equipment fails to operate.

2.3.2 Preventive Maintenance Management (Time-Based Maintenance)

According to Sullivan (2010), Preventive maintenance can be defined as the actions performed on a time- or machine-run-based schedule that detect, preclude, or mitigate degradation of a component or system with the aim of sustaining or extending its useful life through controlling degradation to an acceptable level. Preventive Maintenance means replacing components or overhauling items at fixed intervals of time (Mobley, 2004) to prevent unscheduled downtime that would result in repair or corrective activities. This approach to maintenance management is time-driven where tasks are performed to maintain acceptable levels of availability and reliability (Mobley, 2004).

2.4 Other types of Maintenances

2.4.1 Predictive Maintenance (Condition-Based Maintenance)

Predictive maintenance attempts to detect the onset of a degradation mechanism with the goal of correcting that degradation prior to significant deterioration in the component or equipment (Sullivan, 2010).

The diagnostic capabilities of predictive maintenance technologies have increased in recent years with advances made in sensor technologies such as infrared (IR) thermography, infrared thermometer, ultrasonic detection, oil analysis equipment etc. These advanced technologies, breakthroughs in component sensitivities, size reductions, and most importantly, cost, have opened up an entirely new area of diagnostics to the operational and maintenance practitioner.

Sullivan (2010), further elaborates the need of predictive maintenance as can be used measurements that detect the onset of system degradation (lower functional state), thereby allowing causal stressors to be eliminated or controlled prior to any significant deterioration in the component physical state. Basically, predictive maintenance differs from preventive maintenance by basing maintenance need on the actual condition of the machine rather than on some preset schedule. You will recall that preventive maintenance is time-based. Activities such as changing lubricant are based on time, like calendar time or equipment run time. For example, most people change the oil in their vehicles every 3,000 to 5,000 miles traveled. This is effectively basing the oil change needs on equipment run time. No concern is given to the actual condition.

2.4.2 Reliability Centered Maintenance (RCM) (Pro-Active or Prevention Maintenance)

According to Sullivan (2010), reliability centered maintenance has the following definition a process used to determine the maintenance requirements of any physical asset in its operating context. Basically, reliability Centered maintenance methodology deals with some key issues not dealt with by other maintenance programs. It recognizes that all equipment in a facility is not of equal importance to either the process or facility safety. It recognizes that equipment design and operation differs and that different equipment will have a higher probability to undergo failures from different degradation mechanisms than others (Sullivan, 2010). It also approaches the structuring of a maintenance program recognizing that a facility does not have unlimited financial and personnel resources and that the use of both need to be prioritized and optimized. In a nutshell, RCM is a systematic approach to evaluate a facility’s equipment and resources to best mate the two and result in a high degree of facility reliability and costeffectiveness. RCM is highly reliant on predictive maintenance but also recognizes that maintenance activities on equipment that is inexpensive and unimportant to facility reliability may best be left to a reactive maintenance approach. The maintenance program breakdowns of continually top-performing facilities would echo the RCM approach to utilize all available maintenance approaches with the predominant methodology being predictive. Machinery maintenance can often be quite costly in a production plant operation if not properly handled. Maintenance in a broad definition is concerned with controlling the condition of equipment, and very few studies were available describing quantitative or objective methods for arriving at the optimization of the different maintenance strategies. Because RCM is so heavily weighted in utilization of predictive maintenance technologies, its program advantages and disadvantages mirror those of predictive maintenance (Sullivan, 2010). In addition to these advantages, RCM will allow a facility to more closely match resources to need while improving reliability and decreasing cost.

2.4.3 Autonomous Maintenance

Autonomous Maintenance refers to one pillar of the TPM activities that involve operators in maintaining their own equipment, independent of the maintenance department. Activities in an AM program include: daily inspections, lubrication, parts replacement, simple repairs, and abnormality detection and precision checks. It can be referred as CLIT (cleaning, lubrication, inspection and tightening). The goals of the program are to prevent equipment deterioration, restore equipment to its ideal state, and establish basic conditions needed to keep equipment well maintained. AM is one of the most important building blocks in any TPM program. 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.

2.5 Challenges of Maintenance Practices

According to Mobley (2008), Preventive maintenance has long been recognized as extremely important in the reduction of maintenance costs and improvement of asset reliability and maximizing of production outputs. In practice it takes many forms. Two major factors that should control the extent of a preventive program are first, the cost of the program compared with the carefully measured reduction in total repair costs and improved asset performance; second, the percent utilization of the asset being maintained. If the cost of preparation for a preventive-maintenance inspection is essentially the same as the cost of repair after a failure accompanied by preventive inspections, the justification is small. If, on the other hand, breakdown could result in severe damage to the asset and a far more costly repair, the scheduled inspection time should be considered. Furthermore, in the average plant preventive maintenance should be tailored to fit the function of different items of equipment rather than applied in the same manner to all equipment. Key pieces of equipment in many other integrated manufacturing lines are in the same category. Conversely, periodic inspections of small electric motors and power transmissions can easily exceed the cost of unit replacement at the time of failure. Indeed, a program of asset or component replacements can result in considerably lower maintenance costs where complete preventive maintenance is impractical. In a plant using many pumps, for instance, a program of standardization, coupled with an inventory of complete units of pumps most widely used, may provide a satisfactory program for this equipment. This spare-tire philosophy can be extended to many other components or subassemblies with gratifying results. Sometimes, instead of using a centrally administered formal preventive program, qualified mechanics are assigned to individual pieces of equipment, or equipment groups, as mechanical custodians. Operating without clerical assistance and with a minimum of paperwork, these men, because of familiarity with equipment and ability to sense mechanical difficulties in advance, can effectively reduce maintenance costs and breakdowns (Mobley, 2008). These compromise devices can frequently be used to greater advantage, even in plants where equipment is not in continuous operation and a more comprehensive preventive program might be set up. Periodic shutdown for complete overhaul of a whole production unit, similar to the turnaround period in oil refineries, is another method of minimizing breakdowns and performing maintenance most efficiently.

One of the most effective methods of tempering ideal preventive maintenance with practical considerations of a continuous operation is that of taking advantage of a breakdown in some component of the line to perform vital inspections and replacements which can be accomplished in about the same time as the primary repair. This requires recording of deficiencies observed during operating inspections and moving in quickly with craftsmen and supervision prepared to work until the job is done. Production supervision usually can be sold the need for a few more hours' time for additional work with repair of a breakdown much more easily than they can be convinced of its necessity when things are apparently running smoothly.

2.6 Maintenance Practice and Production Performance

Effective maintenance practice involves the use of maintenance staff training process, and establishing and understanding the clear maintenance philosophies, establishing proper standard operating procedures and work instructions in the production process line. A combination of maintenance philosophies, proper training and standard operating procedures creates a significant role in order to enhance and improve production performance in different companies.

According to Steven Boris (2008), the operations or production function has explicit responsibilities that must be provided before maintenance can achieve and sustain world-class performance in production. Some of the responsibilities are Operate machinery and equipment properly, Know the conditions and performance of facilities and equipment, maintain surveillance thereof in order to detect unsatisfactory conditions and anticipate essential work, report malfunctions to appropriate engineering or maintenance personnel for diagnosis and action etc. are some but not limited to.

Current or present maintenance practice requirements, results from gaps between standards and performance of the day to day increase in production volume of an organization. On the other hand, future lean maintenance arises as a result of changes that are going on within or out of the environment that the organization performs. Maintenance practices can determine the gap between the actual level of performance and the desired one in a manufacturing environment.

In general, conducting a research on relationship of machinery maintenance with that of production output has an important purpose of sorting out those problems that could help to alleviate performance issues in production areas in most manufacturing factories.

2.7 Maintenance Costs related with Production Out put

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. This reactive of management forces the maintenance department to maintain extensive spare parts inventories that include spare machines or at least all major components for all critical equipment in the plant. The alternative is to rely on equipment vendors that can provide immediate delivery of all required spare parts. Even if the latter is possible, premiums for expedited delivery substantially increase the costs of repair parts and downtime required for correcting machine failures. To minimize the impact on production created by unexpected machine failures, maintenance personnel must also be able to react immediately to all machine failures.

The net result of this reactive type of maintenance management is higher maintenance cost and lower availability of process machinery. Analysis of maintenance costs indicates that a repair performed in the reactive or run-to-failure mode will average about three times higher than the same repair made within a scheduled or preventive mode. Scheduling the repair provides the ability to minimize the repair time and associated labor costs. It also provides the means of reducing the negative impact of expedited shipments and lost production. In the other hand, Sullivan (2010), states preventive maintenance proper management can bring a saving amount up to as much as 12% to 18% on the average. Depending on the facilities current maintenance practices, present equipment reliability, and facility downtime, there is little doubt that many facilities purely reliant on reactive maintenance could save much more than 18% by instituting a proper preventive maintenance program.

According to Sullivan (2010), explained that there is an estimated value that a properly functioning of predictive maintenance program can provide a savings of 8% to 12% over a program utilizing preventive maintenance alone. Depending on a facility's reliance on reactive maintenance and material condition, it could easily recognize savings opportunities exceeding 30% to 40%. In fact, independent surveys indicate the following industrial average savings resultant from initiation of a functional predictive maintenance program:-

- Return on investment: 10 times
- Reduction in maintenance costs: 25% to 30%
- Elimination of breakdowns: 70% to 75%
- Reduction in downtime: 35% to 45%
- Increase in production: 20% to 25%.

Unlikely, the cost of maintenance activities could be ranged from 15 to 70% of the total production costs (Sullivan, 2010).

According to Taylor (2011), Driving down maintenance costs has in many companies become a mantra and, in some cases, rightly so. However, by reducing maintenance costs alone, you won't necessarily achieve your organization's objectives. Both the company's maintenance's mission and objectives must be factored in. One way is to relate the maintenance costs to the overall cost of production or, where single or similar product lines are produced, to the number of units produced. For example, in interdivisional or interfirm benchmarking, a maintenance costs per ton of output is a widely used figure.

$$Direct\ Maintenance\ Cost\ per\ Unit\ Output = \frac{Total\ Direct\ Maintenance\ Cost}{Total\ Production\ Units} \tag{1}$$

2.8 Machine Efficiency and Performance Measurement

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.

$$Availability = \frac{Total\ Time - Downtime}{Total\ Time} \tag{2}$$

Availability takes into account Availability loss, which includes all events that stop planned production for an appreciable length of time (typically several minutes or longer). Examples include Unplanned Stops (such as breakdowns and other down events) and Planned Stops (such as changeovers). Machine efficiency gives us an indication of how well the production line is running when we intend it to run.

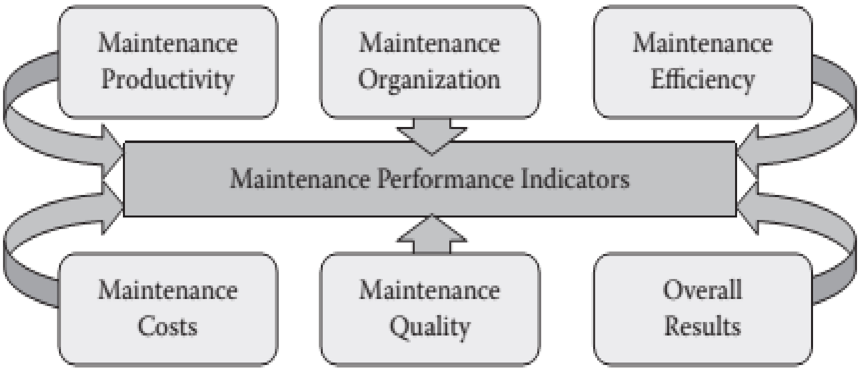
According to (Subramaniam, 2007), Machine efficiency is one of the factors that are frequently overlooked by the management and this can lead towards losses which reduces the yield. Improper maintenance of machines will result in low standards of produced parts and increases the maintenance of machines. Machines are meant to work efficiently, but in some circumstances machines can be less productive due to improper preventive maintenance.

Preventive maintenance is a key factor that keeps the machine running efficiently through the production process. The maintenance activity on machines needs extra attention by the management along with the responsible personnel to ensure optimum usage of machineries which will eliminate unwanted wastages due to machine stoppages.

Machine Efficiency= Value adding time / (Value adding time+ Machine Loss time) (3)

Where Value adding time VAT=Actual produced/Rated speed of the machine (4)

Figure 2. 1 Maintenance Performance Indicator



(Source: Taylor 2011, page 85)

2.9 The Need and Importance of Proper Maintenance Practices

2.9.1 Improving equipment reliability

Total Plant Performance Management (TPPM) and similar quality programs promote a holistic approach that includes equipment performance as a major enhancement to productivity. The fundamental objective is elimination of failures.

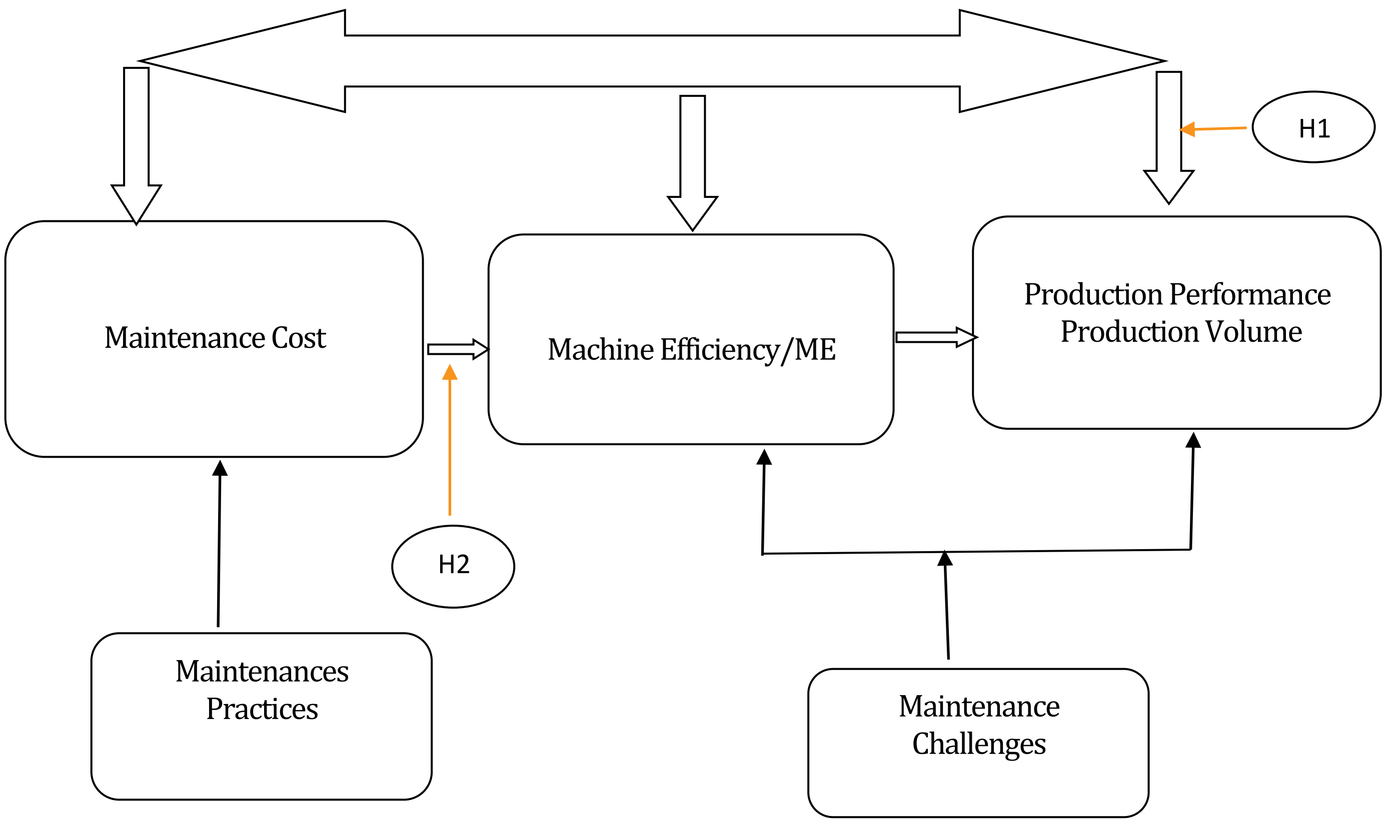
A Successful maintenance organization spends more time on identification of trends and eliminating problems than they spend fixing repetitive breakdowns. For production equipment to be efficient and effective, ensuring the system function is the prime maintenance objective. Maintenance has to provide the required reliability, availability, machine efficiency and capability of production system in accordance to the need of these characteristics. Ensuring system life refers to keeping the equipment in good condition to achieve or prolong their design life. In this case, cost has to be optimized to meet the desired plant condition (Dekker, 1996) as a business improvement process.

2.10 Summary and Conceptual Frame Work

The conceptual frame work helps to simplify the relationships among the variables. The three variables are maintenance cost, machine efficiency and production performance which has a link with the maintenance practices, maintenance challenges. The maintenance practices determines the maintenance cost. Good maintenance practices such as proper preventive maintenance activities leads to less maintenance expenditures and unorganized maintenance activities lead to unexpected breakdown that brings unexpected maintenance cost. The different maintenance challenges have significant influences on production performance. How the variables correlates with production volume are critical for the development and successful implementation of maintenance management system.

This is simplified in the following conceptual framework.

Figure 2. 2 Conceptual framework



Source: (Author, 2017)

Production performance depends on the different attributes of maintenance system and other external factors. However, maintenance produces the capacity for production. The production performance is affected by both the machinery maintenance systems and the machine efficiencies of the production line and the quality of maintenance work. The way maintenance is performed will influence the availability of production machineries, the production volume, quality and cost of maintenance, as well as safety of the operation. In order to test this in EABSC the following hypothesis are proposed.

H1: Maintenance cost has significant relationship with production performance.
H2: Maintenance cost and machine efficiency have significant relationship.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1 Research Design and Approach

This study employs a descriptive research design to investigate and explain on the relationship of machinery maintenance practices with production output on EABSC. 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 from an individual, organizational and industry-oriented perspective. In a similar fashion, the researcher strives to get the analysis of relationship of machinery maintenance practices on production performances, firstly tried to see what are the maintenance behaviors of artisans, emotions, and feelings, contexts of organizational functioning, industrial cultural, and interactions among technical and production staff. Thus for this particular situation, qualitative research approach were utilized. On the other hand, quantitative research approach were very helpful to get details on quantitative values of the variables to investigate and cross check the performance of the production lines whether or not it is interlinked and being affected with the different maintenance activities performed with in the factories. Because of this, a mixed research approach is preferred since it enables the researcher to collect appropriate information in both production and maintenance departments. The research was thus an empirical study and was done through a cross section approach of EABSC production factories. The study can further be described as case study because only EABSC production lines found in Addis were targeted in the research.

3.2 Population and Sampling Technique

3.2.1 Research Population

The research covered all the production lines of EABSC found in Addis Ababa for both production and maintenance staffs. The maintenance team of EABSC has diversified structures under the manufacturing department. The work of the maintenance team is to ensure that the production equipment is in operational mode at all times and breakdowns and related downtimes are resolved and fixed as quickly as possible. The production equipment comprise different technologies such as the infeed crate conveyor system, crate rinser, unpacker/uncaser machine,outfeed empty crate conveyor system,EBI (empty bottle inspection machine),the washer for cleaning the RGB (returnable glass bottles) and crate washer machine, the empty bottle conveyor, the filler for filling of beverages and syrup blending machine ,the full bottle conveyor system, full bottle inspection machine(FBI), date coding machines, the packer/caser machine, the blow molding machine, the spiral bottle conveyors and the full crate conveyor machine which are all integrated to achieve a specific production goal using different Simatic and PLC technologies.

The focus of the research was on the production Managers, technical managers, production team leaders, production operators, technicians, electricians, specialists and maintenance division heads. The unit of sampling and population of the study was the 4 production bottling lines of EABSC found in Addis Ababa. At least 2 respondents from each plant from production and Engineering department were selected making a total of 44 respondents.

3.2.2 Sampling Techniques

A simple random sampling method was used to select respondents for the study. Simple random sampling ensures that each member of the population has an equal chance for selection.

A sample of 40 employees was derived. The determination of the sample was done using Cochran's (1977) formulas. 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:

$$n = \left\{ \frac{t^2(p)(q)}{(d^2)} \right\}$$

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

Where:

n = the desired sample size

t2 = value of selected alpha level of .025 in each tail =1.96 (the level of .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 (.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 44, the required sample is calculated as follows:

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

Where, *n* 0 is the sample size, *N* is the population size and n is the target sample size

Then calculated as:

$$n = \left\{ \frac{384}{1 + (384 - 1) / 44} \right\} = 40$$

3.3 Types of Data and Tools/Instruments of Data Collection

Both primary data and secondary data were collected. Primary data aimed to gather information on level of application of various Maintenance practices and production performances in the factories. The primary data also helps to exploit information on the different challenges of maintenance problems, technical problems affecting production outputs. Secondary data was obtained from the SAP system. All the maintenance costs, maintenance practices, maintenance efficiencies and production volume are extracted and extrapolated from the SAP system for the last two and half years.

Two types of data collection instruments has been used in collecting the primary data. These were questionnaires; open and closed ended questionnaires and self-guided interview questions (source: EABSC for 44 sample size) was prepared with English version and the concepts were taken from the guideline of the maintenance strategy/policy of the company and with some personal experience of the author.

According to Kothari (2004), the questionnaire method is the most suitable tool for collecting data. It is economical in terms of time and cost compared to other methods.

3.4 Procedures of Data Collection

The Researcher relied on primary data using a questionnaire, which was administered by giving orientation and explanation for selected respondent about the purpose of the questionnaire with help of the team leaders and technical managers. There after the respondents were attended on site so as to give them explanation for the respondents in case of ambiguity. The study also relied on 127 observations of secondary data from the four production lines which was gathered data for two and half years SAP report of maintenance and production performances categorized in a weekly and monthly basis in order to get the detail information out of the data. The questionnaires are simplified in order that all respondents have a common understanding and meaning of each of the questions.

3.5 Methods of Data Analysis

The collected data was cleaned, entered and analyzed using IBM SPSS® version 23 for Windows®. Descriptive statistics, and correlation analysis were applied to examine the relationship of machinery maintenance practices and production performances.

Spearman's rank correlation was used to test whether there is an association between maintenance practices and overall production outputs. Spearman's rank correlation was also used to test whether there is correlation between maintenance practice and machine efficiencies based on the inputs of the secondary data.

Spearman rho is calculated using the following formula where there are no tied ranks

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$$

where d_i = difference in paired ranks and n = number of cases. The formula to use when there are tied ranks is:

$$\rho = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}}$$

where i = paired score.

Different charts such as graphs, histogram and pie charts were used to illustrate and compare between various factors such as maintenance practices, maintenance challenges, maintenance cost as well as machine efficiencies with that of production performance. The reliability of the spearman's result will be validated and cross tabulated with the results obtained from the respondents of production and maintenance departments.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Characteristics of respondents

Primary data were collected from 44 respondents who worked in the four production plants with different educational backgrounds, work experience and responsibilities who possess different job category in the company. Secondary data on maintenance cost and production volume for two and half years comprising of 127 observations were extracted from SAP system and then analyzed, triangulated and interpreted by using SPSS software.

4.1.1 Working experience of respondents

Table below indicates the working experience of employees who participated in the study. The objective was to determine how long they have stayed in the company and determine their experience in the maintenance practices. The data gathered shows majority of the respondents, representing 52.30%, have worked for more than four to eight years in EABSC. The mean (+SD) of years of work experience of the respondents was 6.34 (+8) years while the minimum and maximum years of work experience was 2 and 25 respectively. Most respondents 44% who have work experience of greater than four years have said most of the maintenance challenges are caused due to absence in proper reporting. The reporting mechanism is not such convenient and does not create a clear span of control. This means that staffs are reporting to someone who haven’t got the required work experience, skill and knowledge in the specific area that causes challenges in machinery maintenance.

Table 4. 1 Work experience of respondents

Service year	Frequency	Valid Percent
2	4	9.1
3	4	9.1
4	8	18.2
5	8	18.2
6	7	15.9
7	2	4.5
8	3	6.8
10	4	9.1
14	3	6.8

25	1	2.3
Total	44	100.0

(Survey data, 2017)

4.1.2 Current responsibilities of respondents

Taking their responsibilities in to account the majority of the operators, technicians and specialists have responded there is a problem in giving attention towards the details of the machinery. The machinery are not well attended by technicians, operators and specialists in their respective responsibilities areas in order that the minor problems are solved at an early stage. Because of this reason, machines are forced to stop unexpectedly causing the whole production line to stop. In a similar way, only few technical and production managers (14 %) disagree with the assumption that technical staff lacks the required ability to look up and follow up of equipment in detail. Furthermore, the respondents in all job categories agreed the fact that maintenance activities done by artisan have a significant influence n production performance. Most of the technicians and specialists (75%) and technical and production managers (56%) agreed on the idea that they spent an extended time to look for spares parts in the store room respectively. This is to mean the spare parts are not well categorized to be easily searched and found in the material bin. Only 13 % disagree saying the technicians did not spend time to search the spare parts during machine breakdown. Similarly, the managers 75% agreed that the distance from the production area to the spare part store is another challenge that influences the machine stoppages. But the operators and technicians disagree that the distance is insignificant and does not influence the machine downtime.

Table 4. 2 Responsibilities of respondents

Job category	Frequency	Percent
Operators	8	18.2
Technician	10	22.7
Electrical and Mechanical Specialists	6	13.6
Technical Managers	8	18.2
Production Managers	8	18.2
Others	4	9.1
Total	44	100.0

(Survey data, 2017)

4.1.3 Educational Background of respondents

The respondents were asked to indicate their educational background. The purpose was to find out the educational/academic qualifications of employees and its relationship with Maintenance practices. Table below shows most respondents possessed first degree graduates which compromise a percentage of 25% of the total respondents. Among the 15 staffs who are diploma holders about 53 % of them have agreed that most maintenance activities which is done by operators are causing to frequent equipment failure. On the contrary, most disagree that operators are negligent in operation of the machines. On the other way round, most respondents 53% believed that the training provided to the staff is not adequate enough that brings improvement in production area. Only 33 % of the diploma holders disagree training is inadequate. 7 staffs agreed the autonomous maintenance is not participatory and 5 disagree saying there is an autonomous maintenance system that involves operators in every maintenance activities. The first and second degree holders agreed on not having a well predictive maintenance strategy and autonomous maintenance. However, they disagree on the fact that lack of enough spares and well organized maintenance planning and execution.

Table 4. 3 Educational level

Educational level	Frequency	Percent
Diploma	15	34.1
First degree	25	56.8
Second degree	4	9.1
Total	44	100.0

(Survey data, 2017)

4.2 Maintenance Practices at EABSC

This was designed in order to know whether EABSC has the right maintenance policy and strategy to alleviate production problems in the plant. The respondents who are directly involves in the job matter responded that there is lack of predictive maintenance and autonomous maintenance practices which are the critical factors in reducing production downtimes, breakdown and premature equipment failures and maximizing efficiencies of machineries and thereby increasing the production performance of the overall plant. Likewise, even if most respondents agreed that EABSC has the preventive maintenance system, SOP, MWI, and so on, the company did not have an inclusive autonomous maintenance system that involve and participate the machine operators. Therefore, there is a high tendency of machines to be broken down and affect production performance as a result of lack to participating operators in autonomous maintenance system. In addition to this, the company is not using the different tools (such as oil analysis, vibration analysis, chemography analysis, ultrasonic analysis etc) of predictive maintenances to prevent early failures. Most respondents (59.8 %) agreed that there were not such predictive maintenances that help to identify early machine failures. The company doesn't use predictive maintenance technologies and thus technicians are not using advanced condition based monitoring such as oil analysis, vibration analysis, and Chemo graphic analysis to help them predict premature failures.

Table 4. 4 Summary of Practice of maintenance Management at EABSC

Statements	Strongly disagree N (%)	Disagree N (%)	Neutral N (%)	Agree N (%)	Strongly Agree N (%)	Total N (%)
EAB lacks a proper preventive maintenance philosophies and strategies to alleviate productivity problem.	8(18.2)	21(47.7)	5(11.4)	9(20.5)	1(2.3)	44(100)
EAB does not have a well-established maintenance planning and execution	9(20.5)	16(36.4)	5(11.4)	11(25)	3(6.8)	44(100)

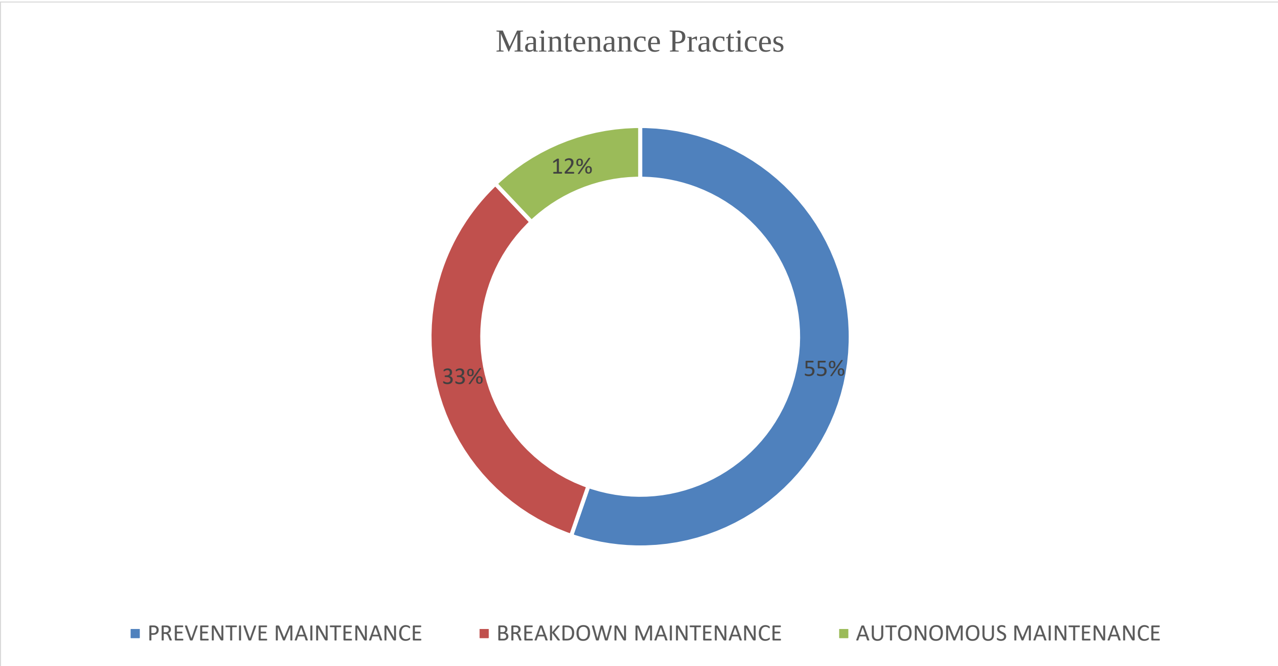
system.						
EAB lacks an autonomous maintenance system that involves and participate the operators.	4(9.1)	8(18.2)	11(25)	13(29.5)	8(18.2)	44(100)
The company does not have an organized way of maintenance controlling and follow up of the maintenance activities.	5(11.4)	26(59.1)	7(15.9)	6(13.6)	0(0)	44(100)
The technicians do not refer documents and manuals of Manufacturers of the machines while doing maintenance activities.	9(20.5)	8(18.2)	8(18.2)	15(34.1)	4(9.1)	44(100)
The company doesn't used predictive maintenance technologies and thus technicians are not using advanced condition based monitoring such as oil analysis, vibration analysis, and Chemo graphic analysis to help them predict premature failures.	4(9.1)	10(22.7)	7(15.9)	15(34.1)	8(18.2)	44(100)
EAB don't have SOP (Standard operating procedure) for both maintenance and production activities to enhance productivity.	8(18.2)	23(52.3)	9(20.5)	3(6.8)	1(2.3)	44(100)
EAB lacks a well-organized PM maintenance schedules and strategies to enhance the required productivities.	6(13.6)	19(43.2)	8(18.2)	9(20.5)	2(4.5)	44(100)

(Survey data, 2017)

On the other hand, most of the respondents agreed (about 52.3%) that the technicians, specialists and operators lack the ability to maintain their machines using the product and equipment instruction manual. Absence of looking up and following up of the right documents and manual instructions are expected to bring operational and technical failures due to the fact that the proper maintenance and operational instructions might be skipped. The technicians do not refer documents and manuals of Manufacturers of the machines while doing maintenance activities. Thus, 60.2 % of the total respondents agreed that the company lacks participating the operators in an autonomous maintenance system so as to minimize downtimes and maximizing production outputs.

The secondary data which was extracted from SAP system shows that the major maintenance which is undertaken in EABSC is the planned maintenance followed by breakdown maintenance (Run to failure maintenance). A proper implementation of planned maintenance strategies results in reduced maintenance cost and avoiding of unplanned machine stoppages. However, in the context of this data, it will be difficult to conclude that the maintenance planning and scheduling are resulting in an improvement in production performance due to the fact that the breakdown of the machine failure is relatively the same as the planned maintenance undertaken in the company.

Figure 4. 1 Actual distribution of Maintenance Practices followed by EABSC



Source: EABSC SAP System (Year 2015-2017)

To gain insight into the maintenance practices employed in the EABSC the Secondary data shows that there is enough planned maintenance (55%) work scheduled in the plant. In the other hand, autonomous maintenance is not well established by involving the operators.

4.3 Challenges of Machinery Maintenance

Lack of proper Maintenance practices has a direct influence on production goal achievement. Improper machinery maintenance will lead to an extended downtime, higher maintenance cost, poor product quality, less yield and less production output related effects. The respondents who are from production and engineering have been requested if there are issues related with maintenance that Challenges them not to bring the required production output.

Table 4. 5 Summary of challenges of Maintenance

Statements	Strongly disagree N (%)	Disagree N (%)	Neutral N (%)	Agree N (%)	Strongly Agree N (%)	Total N (%)
The technicians are lacking attention to details and they are only concentrating towards a quick repair work towards equipment failure.	7(15.9)	11(25)	7(15.9)	7(15.9)	12(27.3)	44(100)
The existing tools are aged and do not help to fix the machines during Maintenance work.	4(9.1)	15(34.1)	6(13.6)	17(38.6)	2(4.5)	44(100)
The distance of the machines from the store room does not have significant role in influencing the machine stoppage.	5(11.4)	20(45.5)	6(13.6)	11(25)	2(4.5)	44(100)
Priority is not given to maintenance plan and the priority is given to production without ensuring good maintenance practice.	5(11.4)	9(20.5)	8(18.2)	11(25)	11(25)	44(100)
The management does not allocate enough maintenance period and there is a high level of urgency during maintenance time.	6(13.6)	9(20.5)	12(27.3)	13(29.5)	4(9.1)	44(100)
The management doesn't give enough attention to training of the manpower	7(15.9)	14(31.8)	8(18.2)	12(27.3)	3(6.8)	44(100)

to improve the technician capabilities.						
The reporting hierarchy is less convenient to bring about the maintenance and production improvement.	7(15.9)	10(22.7)	5(11.4)	15(34.1)	7(15.9)	44(100)

(Survey data, 2017)

4.3.1 Challenges related with Operator and Technicians

Considering looking and checking machinery regularly, most have responded (about 43.2%) that there is lack of giving attention to detail. Production becomes idle because the production equipment stopped due to not giving a due attention towards small issues (small machine problems) which latter become big problems that completely bring a catastrophic failure and in turn stops the production of the whole process line. The operators, technicians, specialists are responsible in their respective areas to look after the equipment before deterioration of components occurred.

4.3.2 Challenges related with Management

Considering the priority to maintenance plan, most respondents (50%) have agreed that management does not focus towards maintenance plan. Instead, they give priority to production plan and there is a high level of urgency during maintenance period to start production without ensuring good maintenance practices. The reporting hierarchy is not convenient as well. The respondents (50%) feel that they are reporting to someone who is not competent in supervision and leadership knowhow. The reporting hierarchy is not such suitable so as to instruct subordinates, to make a maintenance proper execution of tasks to bring tangible results in the production environment.

4.3.3 Challenges related with Tools, spare parts and other conditions

In a similar way, the tools utilized for dismounting and repairing of the machine are aged and most respondents about 43.2 % have agreed that the tools are not convenient to make appropriate maintenance activities. Time spent to search the spare parts in the material bin in the store room, the distance from the production area to the spare part store is also another challenge which influences the production performance. On the other hand, the respondents were asked if maintenance problem has a link with material qualities and inputs. Most of them about 52.3% have disagreed that there is no relationship that leads to production performance loss.

On an interview held with the respondents, for the direct question asked ‘’what are the major challenges of production downtime?”, most have responded (80%) that the major challenges are lack of spare parts due to absence of foreign currency by confirming most spare parts are imported from abroad and are not available on time. Thus, Machinery are forced to be maintained with a modification work that accelerates equipment failure and minimizes the production performance of machinery. The distance of the production area from the store room had a significant role in influencing the machine stoppage. Machines are stopped during which the technicians travel to spares store to bring the needed spare in order to fix the machine. The time spent to travel to spare part store is another challenge that influences the production performance.

Table 4. 6 Unplanned Equipment Downtimes

TYPE OF FAILURE	REASON OF DOWNTIME
1) EQUIPMENT FAILURE (EP)	Major factors are breakdowns due to lack of proper PM, skill and technical knowhow, spare shortages, quality of spares, distance of spare parts store from production area ,poor quality of PM, lack of proper tools etc
2) OPERATIONAL FAILURE (OPF)	Component quality problems(Dirty bottles, bad quality of closures, labels, crowns , preforms, damaged crates, broken bottles etc) that causes unplanned machine stoppages.
	Utility and Power related factors (Generator, electric power, compressor, water supply, air supply, Co2 Supply etc.).All downtimes related with power interruption that causes machines to be stopped production without planned job.
	Setting and adjustment(setting and adjustment of related with operator skill, improper adjustment etc)

	Others (Forks lifts, shortage, space shortage, warehouse shortage, way blockage, man power shortage etc)

According to Mobley (2008), lack of improper implementations of preventive maintenance and planned maintenance strategies will lead to an unscheduled downtime, and an increased maintenance costs by substantially decreasing of production performance both by quantity and quality. 35% of the downtimes are caused by machine failure due to absence in implementing proper preventive maintenance policies and strategies. On the other hand, there are various reason of machine stoppages that causes the production line to cease its production as per the illustration in the table below.

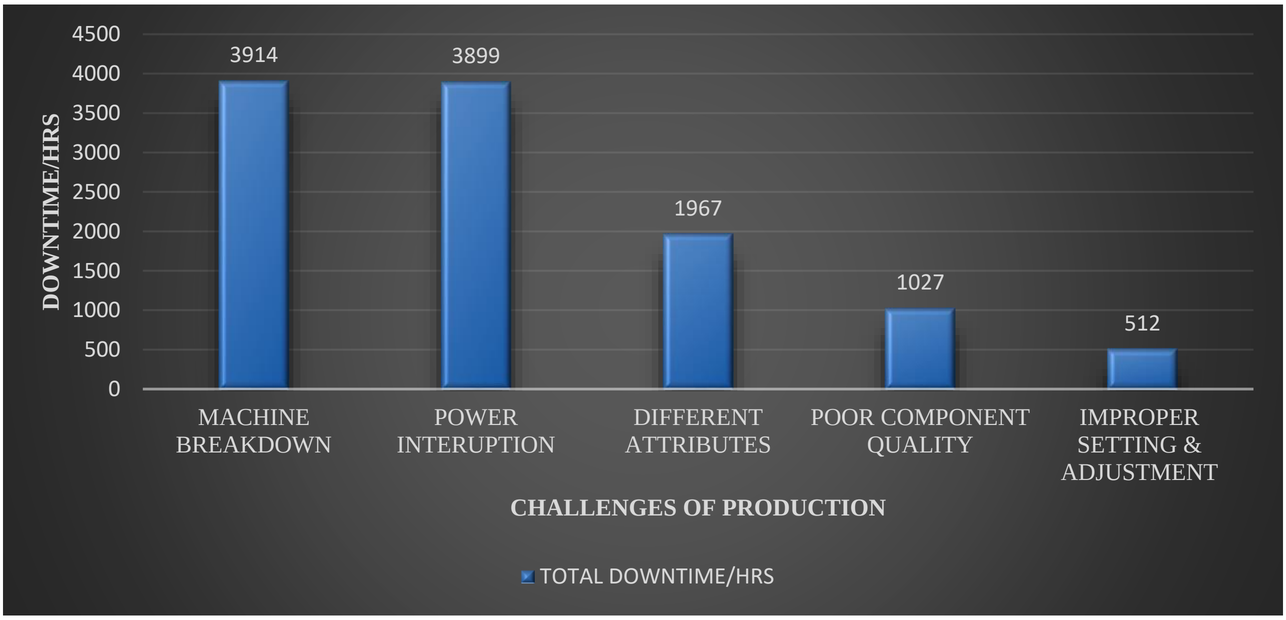
In contrast to the respondents view, the result shows that the operational equipment downtimes were the significant factor which influences the production performances after machine Failure.

Table 4. 7 Challenges of production performance losses

Types of Down time	YEAR/Downtime/Hrs			Minimum	Maximum	Mean	Std. deviation	Variance
	2015	2016	2017					
Equipment Failure	1588	1559	1534	1534	1588	1561	24	576
Component quality problem	394	273	720	273	720	476	204	41616
Utility and Power interruption problem	2180	1232	974	974	2180	1508	557	310249
Incorrect setting and adjustment Problem	239	223	100	100	239	180	66	4356
Shortages related with manpower shortage, warehouse space shortage,	572	956	878	572	956	787	178	31684

(Source: EABSC SAP data, 2015-2017)

Figure 4. 2 Bar Chart showing the most critical challenges of production.



(EABSC SAP data, 2015-2017)

The basic underlying principles of the above chart is that 80% of the total production problems or production losses which are incurred in EABSC are caused by 20% of the major downtimes which are problems caused by poor maintenance practice or Breakdown (35%) and power related issues(34%). Therefore, by concentrating on the major problems at the first stage, we are able to eliminate the majority of the problems. Likewise, among the different operational downtimes, the major factors influencing machine to stop are the external power related factors (34%) such lack of power supply (power interruption causing different issues), generator stoppages, water supply, lack of air and Co2 supply due to power interruptions and 17% of the production effect is caused by manpower shortage, forklift shortage, warehouse space problems and other related issues. Lack of good component quality of the different inputs of raw materials and improper setting and adjustment due to operator error constitutes 9% and 5% respectively which are considered to be the challenges influencing the production performance losses.

4.4 Relationship between Machinery maintenance and production performance

Table 4. 8 Maintenance cost, machine efficiency and production volume (year based)

S/No	Variables	Year			Mean
		2015	2016	2017	
1	Production quantity/cases	29,479,880	30,279,688	33,588,308	31,115,959
2	Maintenance Cost/ETB	26,798,471.55	33,140,491.8	34,377,820.8	31,438,928
3	Average Machine Efficiency (%)	88.90	91.20	95.00	92

(Source: EABSC SAP data, 2015-2017)

Note: Cases is a crate containing of 24 bottles/It is used to measure the amount of production.

There is a huge difference on the minimum and maximum values of maintenance cost which shows irregularity during the maintenance period. Likewise, the production performance is relatively good compared with the maintenance cost.

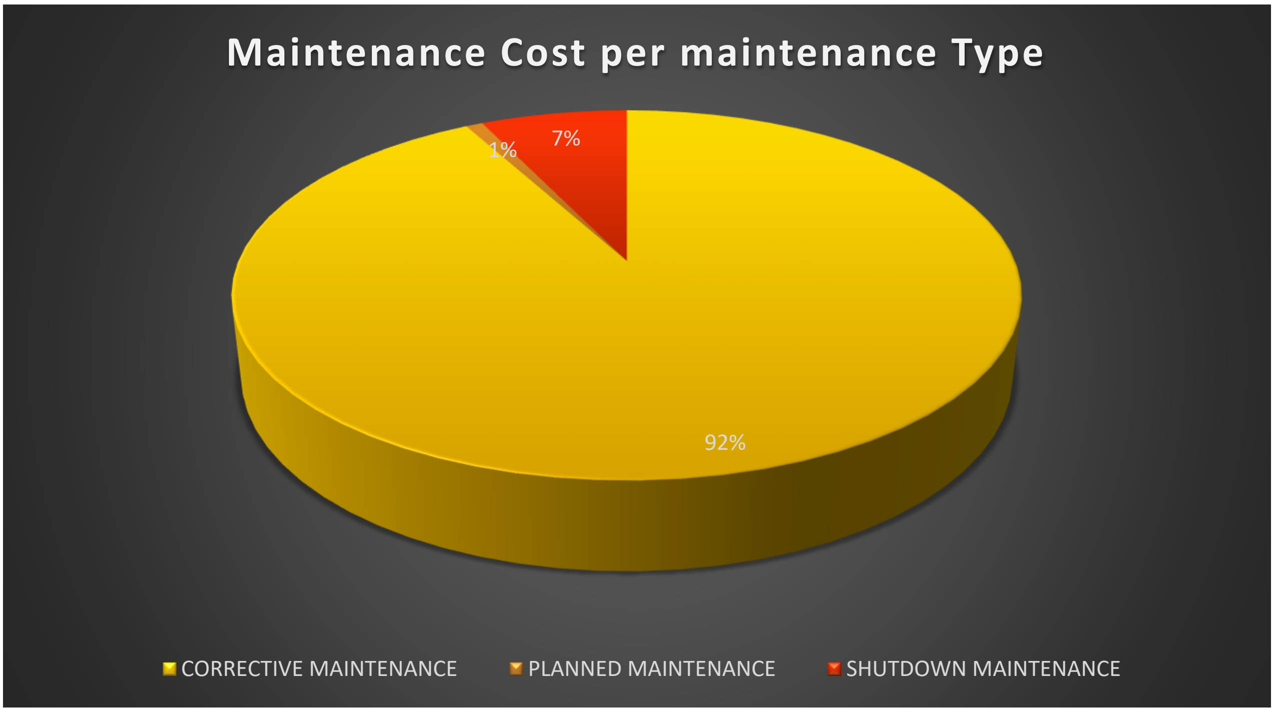
Table 4. 9 Descriptive statistics of MC, PQ and ME

	Minimum	Maximum	Mean	Std. Deviation	Variance
MC(ETB)	283,831	12,781,312	2,503,779.47	2,542,080.13	6462171384576.03
PQ(CASES)	793917	3461297	2106620.97	691475.67	478138597847.82
ME (%)	82	97	91.10	4.27	18.25
N					

(Source: EABSC SAP data, 2015-2017)

The figure below shows that the cost of corrective maintenance is much higher than the cost of preventive maintenance and shutdown maintenance costs combined. This implies that the equipment's are not maintained with a proper maintenance planning and scheduling. Instead, the machines spare replacement is undertaken when the failure has already happened and known. This contradicts with the fact of respondents in that the maintenance undertakings is more towards a breakdown maintenance than a time based maintenance. We can conclude that, the maintenance planning and scheduling priority is less compared with production priority. The maintenance period is not adequate enough to ensure good maintenance practices in order to bring about an improvement in production quantities.

Figure 4. 3 Maintenance cost distribution per maintenance type at EABSC

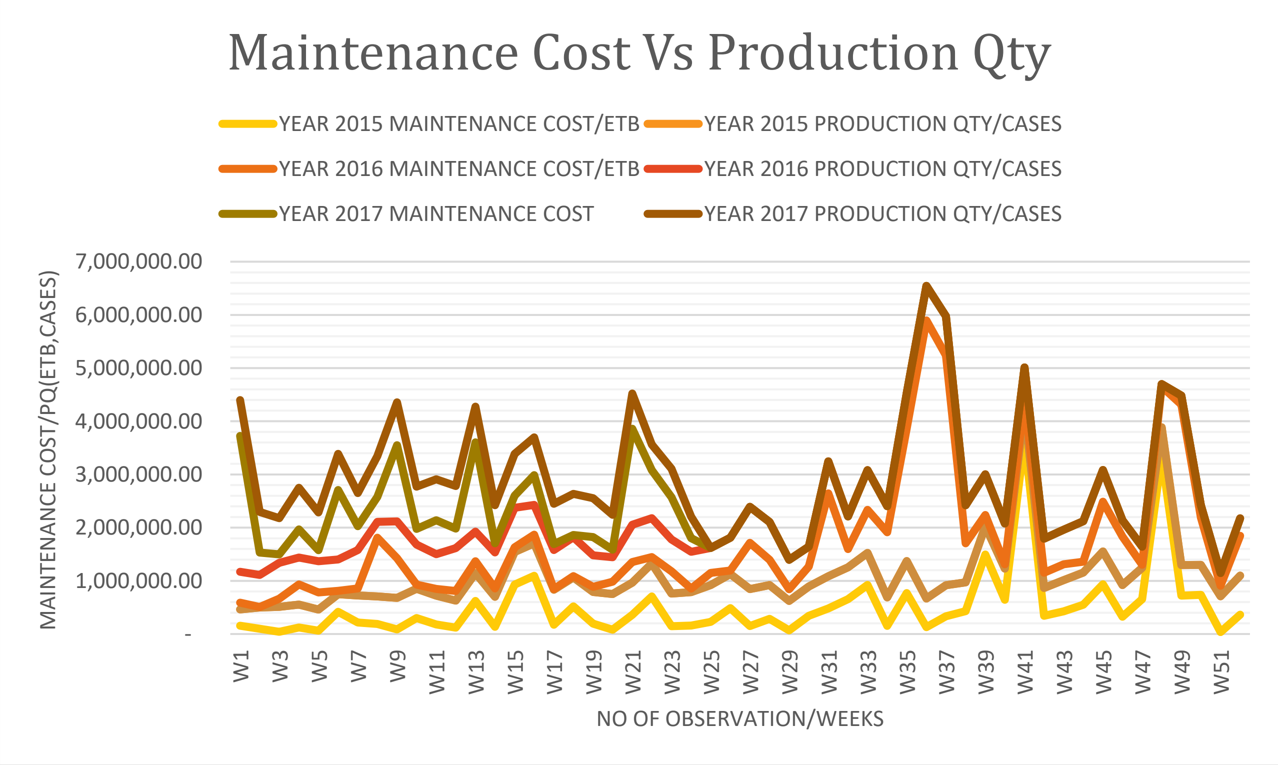


(Source: EABSC SAP data, 2015-2017)

On the other hand, even if predictive maintenance cost is less compared with breakdown cost and other types of maintenances, it is clear that the practice of good maintenance culture brings about a less spare parts expenditure in the production areas. Thus, in order to bring less maintenance costs (minimize breakdowns) in the manufacturing environment, the preventive maintenance practice should be encouraged and enhanced to result a maximum production output. The result shows that 92 % of the total maintenance cost carried out at EABSC is corrective maintenance and 7 % of the maintenance cost is shutdown maintenance which is the cost of maintenance activities during which the machine was stopped due to absence of production schedule. Only 1 % of the total cost is spent by properly planning of the equipment during maintenance time. Failure to perform effective preventive maintenance tasks such as inspections, lubrication, calibrations, and adjustments resulted unsustainable production performance and therefore must be performed in a timely manner to sustain reliable asset operation. Failure to adhere to these schedules and effective execution of these tasks result in reduced asset reliability and production performance.

4.4.1 Relationship of Maintenance cost and Production Volume

Figure 4. 4 Comparison of maintenance cost and production volume/Year based

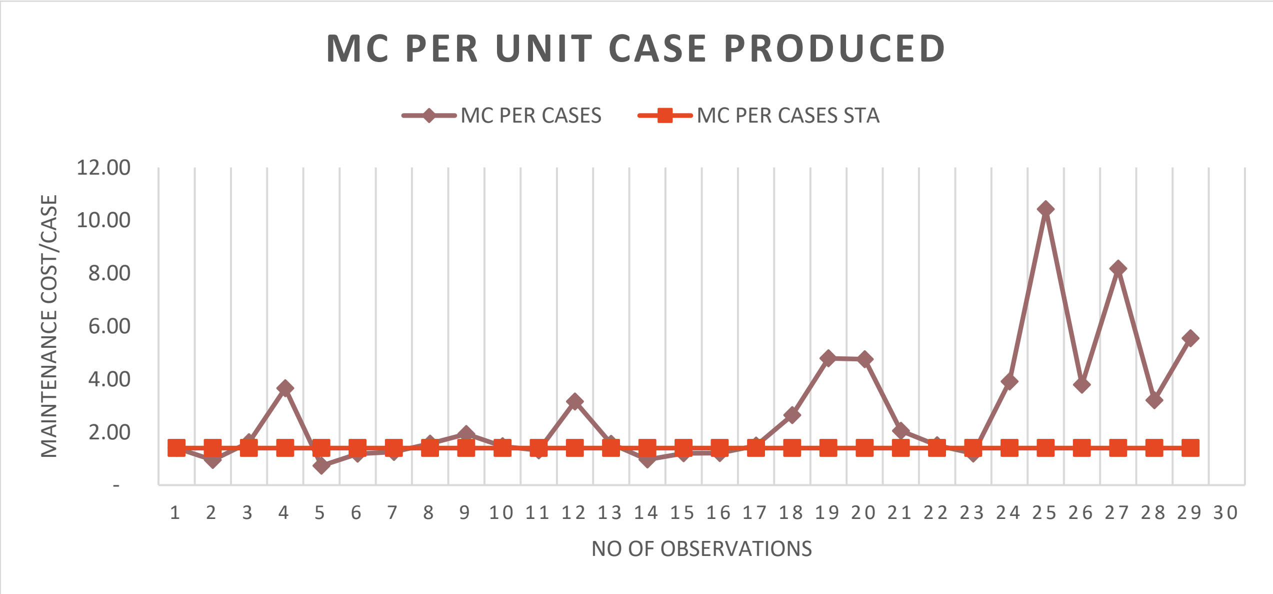


(EABSC SAP data, 2015-2017)

The figure above shows, the year based (from 2015 to year 017) maintenance costs and its respective production output which are segregated in a weekly basis. There are some extreme irregularities with in the graph showing a huge amount of maintenance cost did not correspond an increase in production performance and vice versa. In a similar fashion, there were some indications that a small maintenance cost reveals an increase in production volume. Therefore, the relationship between maintenance cost and production performance did not have a positive linear relationship.

The result shows that maintenance cost have a negative spearman's correlation coefficient with production output. An increase in Maintenance cost and spare part replacement in a particular machinery and production line might not necessary brings an increase in production output.

Figure 4. 5 Comparison of ratio of Maintenance cost per unit case



(Source: EABSC SAP data, 2015-2017)

The result shows the ratio of maintenance cost per unit of cases produced compared with the standard unit of production for a single unit cases varies significantly (refer equation 1). The maintenance cost spent for producing a unit of case is much higher than the standard cost of production.

Table 4. 10 Descriptive statistics of PQ and MC

	Minimum	Maximum	Mean	Std. Deviation	Variance
MC	9,725	5,229,441	594,896.16	830,282.542	689369099859.975
PQ/Cases	45,224	80,8279	599,108.59	137,869.782	19008076711.355
N /Weekly					

(Source: EABSC SAP data, 2015-2017)

The minimum and maximum values of Maintenance cost and production quantities are 9,725 ETB and 5,229,441 ETB and 45224 Cases and 808279 Cases with a standard deviation of

830,282 and 137,869 respectively. This showed there exists a great deal of variation in bringing the maintenance cost convert into the desired production output.

Table 4. 11 Spearman's rank Correlation of maintenance cost with Production output.

Correlations

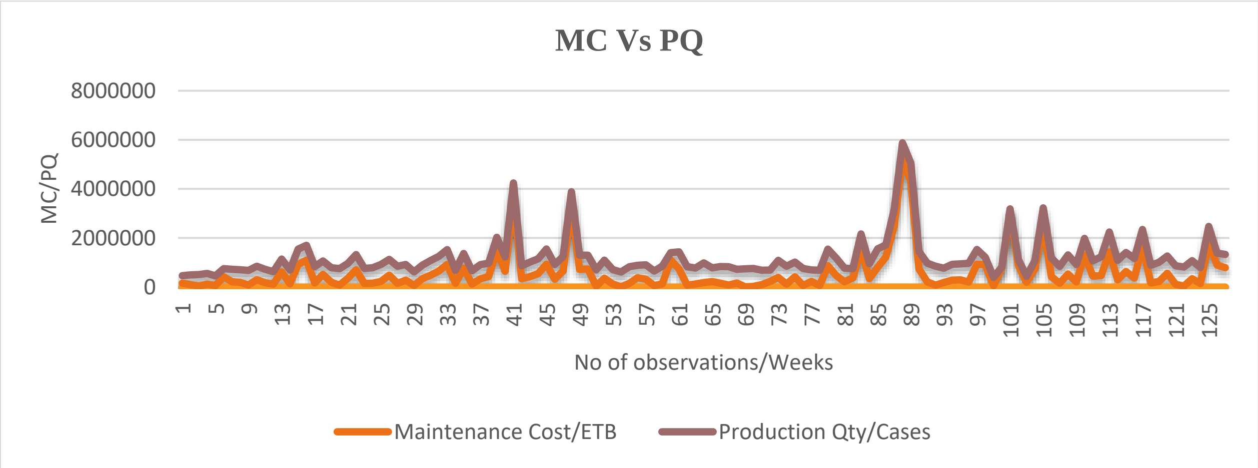
			MC	PQ
Spearman's rho	MC	Correlation Coefficient	1.000	-.083
		Sig. (2-tailed)	.	.351
	PQ	Correlation Coefficient	-.083	1.000
		Sig. (2-tailed)	.351	.

(Source: EABSC SAP data, 2015-2017)

From an observation of 127, the result shows that the spearman's correlation coefficient's is -0.083. This implies that there is a very weak correlation between the maintenance cost and production volume which can be expressed as the spare part expenditures and replacements in the production equipment's are insignificant in bringing production improvements.

To understand the relationships of maintenance cost and maintenance frequencies on overall production performance spearman rank correlation was done. The results showed a negative correlation of -0.083 and a P= 0.351 at α=0.05. The calculated t –Test was -.056 against critical t value of 0.958.

Figure 4. 6 Comparison of maintenance cost with Production output



(Source: EABSC SAP data, 2015-2017)

Thus, the null hypo thesis is rejected and accept that maintenance cost has insignificant correlation with production performance.

4.4.2 Relationship of maintenance cost with machine efficiencies

The results for the comparison of the maintenance cost and machine efficiencies showed that as the plant maintenance cost and spare part replacement increases, the machine efficiencies is expected to increase which results in an increase in production volume. Thus, a positive Spearman's rho correlation coefficient of 0.102 was obtained.

Table 4. 12 Spearman's rank correlation for maintenance cost against machine efficiencies

			MC	ME
Spearman's rho	MC	Correlation Coefficient	1.000	.102
		Sig. (2-tailed)	.	.599
	ME	Correlation Coefficient	.102	1.000
		Sig. (2-tailed)	.599	.

(Source: EABSC SAP data, 2015-2017)

To further check the influence of maintenance cost and maintenance frequencies on overall machine efficiency spearman rank correlation was done. The results showed a positive correlation of 0.102 and a P= 0.599 at α=0.05. The calculated t –Test was 0.884 against critical t value of 5.304. Therefore, the correlation is significant which accepts the hypothesis.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of the findings

The study established that 55% of maintenance carried out in in EABSC is preventive maintenance while 35% of the major challenges of unplanned equipment downtime that causes production performance loss is caused by unexpected breakdown of machinery. 34% of machinery downtimes are caused by power interruption and related issues. The majority of the maintenance cost around 92% is covered by corrective maintenance. This cost implies that the maintenance activities are done mostly after the machine stoppage. The study found that an increased breakdown and corrective maintenance cost are due to improper planned maintenance, predictive maintenance and autonomous maintenance implementations in the factory. The study also showed that there is positive correlation between the maintenance cost and machinery efficiency. The study also showed that there is negative correlation between the maintenance costs with that of production volume.

The study established that the challenges of machinery maintenance are lack of spare parts, distance of the production machinery from the spare part store, lack of good component quality, frequent power interruptions and sudden breakdowns due to absence in following up and giving attention to detail during PM work. On the other side, the maintenance practices lacks participating of operators in autonomous maintenance and using predictive maintenance technologies so as to prevent premature failure of equipment.

5.2 Conclusions

In conclusion it can be deduced from that study 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.

5.3 Recommendations

Taking the study into consideration, the techniques and philosophies and strategies of machinery maintenance has a significant role in influencing the overall business objectives. It is clear that maintenance is not only about ensuring proper functioning of machineries but also ensuring good maintenance practices through a support service function that combines an administrative and technical management system. Hence, from the study result it is better and more advantageous to the company to reduce maintenance costs by implementing the different maintenance activities and strategies specially that of predictive maintenance and autonomous maintenance which is part of TPM by training and participating of operators through engagement in order to improve the production process of EABSC as a whole.

It is such clear that, having a well-established and organized maintenance system should be considered in the company to further outline maintenance significance and its roles in production performance. Thus, the implementation of predictive maintenance and autonomous maintenance in the company is inevitable in the existing production system in order to reduce production losses, decrease early machine failures, and minimize product defect and machine down time, at the same time increasing production volume to maximize the company's overall business objectives.

It is further recommended that, the implications of seasonal dynamics to production output and machine efficiencies need to be carried out in order to reach into a base line that is inclusive to all other several business sectors.

REFERENCES

Alsyouf, I. (2004). Cost Effective Maintenance for Competitive Advantage, PhD. dissertation (Terotechnology), Sweden. Växjö University Press, Acta Wexionensia.

Al-Najjar, B., Alsyouf, I., Salgado, E., Khoshaba, S. & Faagorg, K. (2001). The economic importance of maintenance planning when using vibration-based maintenance. Växjö University, Terotechnology. Växjö University, Sweden.

Al-Najjar, 2010, maintenance impact on production profitability, a case study, TEK 028/2010,VaxJo university ,Sweden

Bellgran, M., & Säfsten, E. K. (2010). Production System Development. Springer, UK.

Bob Vavra, 2016, digital report, maintenance strategies, Maryland

Campbell, J.D., (1995). "Uptime, strategies for excellence in maintenance management. "Portland, OR: Productivity Press.

Chenhall, R.H. (1997), ``Reliance on manufacturing performance measures, total quality management and organizational performance", Management Accounting Research, Vol.8, pp. 187-206.

Cochran, W. G. (1977). Sampling techniques (3rd ed.). New York: John Wiley & Sons.

Dekker, R., (1996). Application of maintenance optimization models. A review and analysis.

Duffuaa, Salih, 2010, Raouf, A. Enriches the understanding of maintenance as (et al.)

Dr David Baglee, 2010, Maintenance Strategy Development in the UK Food and Drink Industry AMAP School of Computing and Technology University of Sunderland.

EN 13306: 2001 – Maintenance Terminology

Elsevier Inc. Elsevier ,2004, Butterworth–Heineman 200 wheeler Road, Burlington, MA 01803, USA Linacre House, Jordan Hill, Oxford OX2 8DP, UK, 2nd Edition

Good well Muyengwa, 2015, analyzing adoption of maintenance strategies in manufacturing companies, International association of management and technology South Africa

Gustav Fredrksson, 2012 , An analysis of maintenance strategies and development of a model for strategy formulation , a case study , Sweden

GP Sullivan AP Melendez, R Pugh WD Hunt, 2010, Operations & Maintenance Best Practices – A Guide to Achieving Operational Efficiency (Release 3.0)

Hang Pham, 2003, Handbook of reliability Engineering, ISBN1-85233-453-3, London

Heinz P Bloch, Fred K Geitner (GPP, 2005, Machinery Component Maintenance and Repair 3rd edition.

Ilhan Yu; Kyungrai Kim; Youngsoo Jung, and Sangyoon Chin,2007, "Journal of Management in Engineering", Vol. 23, No. 3, July 1, 2007

Jorge M.Simoes, 2008, a literature review of maintenance performance measurement, 3754-001 Barro- Portugal

John Day, Ricky Smith, 2015, the Proactive Maintenance Function

Joseph Xavier Francisco Ribeiro, 2011, status of production equipment maintenance engineering in the ghanaian manufacturing industry, Thesis

John D, Campbell ,Andrew K.S.Jardine , Joel McGlynn,2011, asset management excellence Optimizing Equipment Life-Cycle Decisions, by Taylor & Francis Group 6000 ken Sound Parkway NW, Suite 300 Boca Raton, FL 33487-2742, USA

Kelly, A ., (1998). "Maintenance strategy, Business centered Maintenance." Oxford: Reed Educational and Professional Publishing

Kothari, C. R. (2004). Research Methodology: Methods & Techniques. New Delhi: New Age International (P) Limited Publishers

Malaki Radol Opondo Oganga, 2013, performance measurement practices and maintenance improvement among coca cola bottling plants in Kenya, thesis

Makaki Radol, 2013, Performance measurement practice and maintenance improvement among coca cola bottling plants in Kenya, D61/66931/2011, Kenya

Maintenance Practices in Indian Manufacturing Industries, Article · July 2013

Maintenance Best Practices for Outstanding Equipment Reliability and Maintenance Results, life time reliability solutions, from the Maintenance Planning and Scheduling for World Class Reliability and Maintenance Performance, 3-Day Training Course

Miller, P. (1991). Motivation in the Workplace. Work and Organizational Psychology. Oxford: Blackwell Publishers

Obamwonyi Martyn Enofe Gregory Aimienrovbiye, 2013, Department of Terotechnology (Total Quality Maintenance)

Obaid Ahmed Mohamed, 2015, identifying the Barriers affecting quality in maintenance with in Libyan manufacturing organizations, Libya

Parida, A. (2006), "Study and analysis of maintenance performance indicators (MPIs) for LKAB", Journal of Quality in Maintenance Engineering, Vol. 13 No. 4, pp. 325-37.

Parida, A. and Chattopadhyay, G., 2007. Development of a multi-criteria hierarchical framework for maintenance performance measurement (MPM). Journal of Quality in Maintenance Engineering, 13 (3), 241–258.

R.Keith Mobley, 2004, Maintenance Fundamentals, second edition, Amesterdam

R. Keith Mobley ,2008 , Maintenance Engineering hand book , Editor in Chief Lindley R. higgins Darrin J. Wikoff , Seventh Edition, DOI:10.1036/007/546464, New York Chicago

Steven Boriss, 2006, Total productive maintenance, New York Chicago San Francisco Lisbon London Madrid Mexico City Milan New Delhi San Juan Seoul Singapore Sydney Toronto.

Solomon Karanja, 2009, maintenance practices and performance of power, a thesis in Kenya.

Saunders, M., Lewis, P., and Thornhill, A., 2007. Research methods for business students.Harlow, Essex, England: Pearson Educational Limited.

S. K. Subramaniam, S. H. Husin , Y. Yusop 3,A. H. Hamidon , 2006, Machine efficiency and man power utilization on production lines,

S.Anil Kumar (professor),Suresh (ph.D) associate professor,2008, Production and operation management , second edition, new Delhi, Bangalore, New Age International (P) Ltd., Publishers

Tsang, A.H.C., 1999. Measuring maintenance performance. A holistic approach. International Journal of Operations and Production Management, 19 (7), 691–715.

ANNEX-1

Table 4. 13 Relative comparison of Maintenance cost, Production quantity and Machine efficiencies/Monthly basis

YEAR 2015			
MONTH	**MAINTENANCE COST/ETB**	**PRODUCTION QUANTITY/CASES**	**MACHINE EFFICIENCY ,ME%**
JAN	484,294.85	1,602,404.00	83.60
FEB	910,496.99	2,204,233.00	93.70
MAR	1,359,760.10	1,986,320.00	87.90
APR	2,716,164.93	1,902,173.00	82.20
MAY	1,344,015.69	2,473,239.00	92.30
JUN	1,020,421.85	2,849,615.00	92.00
JUL	846,315.30	2,306,379.00	95.00
AUG	2,210,621.65	1,982,418.00	82.00
SEP	1,663,220.93	2,337,762.00	87.00
OCT	6,152,135.46	2,164,641.00	88.00
NOV	2,888,734.40	2,013,725.00	88.50
DEC	5,202,289.38	2,529,641.00	95.00
YEAR 2016			

MONTH	MAINTENANCE COST/ETB	PRODUCTION QUANTITY/CASES	MACHINE EFFICIENCY ,ME%
JAN	994,401.43	2,362,316.00	94.5
FEB	2,040,657.68	2,198,406.00	91.5
MAR	762,510.86	3,461,297.00	88.6
APR	283,831.03	2,272,033.00	92.4
MAY	840,380.44	2,188,439.00	92.8
JUN	777,184.02	2,826,437.00	89.2
JUL	1,937,498.59	2,243,361.00	86.6
AUG	3,939,832.80	2,160,350.00	93.0
SEP	12,781,312.24	2,641,900.00	87.8
OCT	759,125.67	2,737,578.00	90.5
NOV	2,406,079.36	2,822,290.00	95.6
DEC	5,617,677.76	2,653,939.00	92.8
YEAR 2017			
MONTH	**MAINTENANCE COST/ETB**	**PRODUCTION QUANTITY/CASES**	**MACHINE EFFICIENCY ,ME%**
JAN	3,873,748.15	908727	97.2
FEB		825071	96.8

	3,656,608.48		
MAR	3,150,554.03	793917	97.2
APR	943,440.11	817219	94.4
MAY	1,046,290.44	826178	93.9

Appendix I: Questionnaire

Questionnaire to be filled in by Employees.

Dear Participants:

I am conducting a research on the topic "The relationship between machinery Maintenance and production performance in case of EAB Sh.co" for the fulfilment of the **Master Program for Business Administration in General Management**. Dear participants, hence, I kindly request you to fill in the questionnaire honestly and to provide the 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 cooperation in advance.

Section A: General Information

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

1. Educational background: Diploma ☐ First-degree ☐ Second degree ☐
   Terminal degree, other (specify) ☐ ______________________________
2. Service year in EAB SC: Years______________________________
3. Current Position category: Operator ☐ Technician/Artisan ☐ specialist ☐
   Technical management ☐ production management ☐ other (specify) _________________

Section B: General Instruction

Here under question statements related to Maintenance challenges and practices and its influences on production performance, the philosophies and challenges of maintenance practice at EAB SH.CO in providing the required production capacity, the influence of Maintenance management and maintenance practice on the overall production performance, and the significant roles that maintenance practice bring/play on production performance. Hence, you are kindly requested to tick (√) the most appropriate response for each of the question statements found under each part in the table below with the following scores in mind. 1-Strongly disagree, 2-disagree, 3- neutral/Undecided, 4- agree, 5- strongly agree.

Table 4. 14 Table of maintenance practices Questionnaire and Interviews

Part I. The Maintenance Challenges of EAB SC.	5strongly agree	4 agree	3 Neural	2disagre	1strongly disagree

i.	Maintenance which is done usually by operators mostly leads to frequent machine breakdown.					
ii.	The operators are negligence up on operation of the machines.					
iii.	The operators assigned to run the machines lack the right qualification and experience.					
iv.	The machines lack the required technical and design problem to run with the full capacity.					
v.	The technicians/Artisans do not have the required knowledge, skills and experience to repair the machines quickly during machine failures.					
vi.	The technician’s maintenance skill is limited because they are promoted without having the right technical assessment.					
vii.	When machines broke during emergency maintenance, the technicians do not know the spares needed for the machines to be repaired.					
viii.	The technicians are lacking attention to details and they are only concentrating towards a quick repair work towards failure (a fire fighting repair).					
ix.	There is a total negligence of technicians/Artisans when following up the machine in their responsibility areas.					
x.	The tools to work with the machines are not the right ones to help technicians dismount with the parts.					
xi.	The existing tools are aged and do not help to fix the machines during Maintenance work.					
xii.	There are inadequate spare parts to maintain the machines to previous conditions.					
xiii.	The technicians/specialist do not spend extended time for searching the spares in the material bin during breakage and it takes an extended time to repair the machines.					
xiv.	The qualities of the spare parts are not good enough and					

	won't last long when mounted in the machine.					
xv.	The distance of the machines from the store room does not have significant role in influencing the machine stoppage.					
xvi.	Priority is not given to maintenance plan and the priority is given to production without ensuring good maintenance practice.					
xvii.	Maintenance practice is little affected by the quality of raw materials such as crowns, reforms, any other raw materials input to the machine etc.					
xviii.	The management does not allocate enough maintenance period and there is a high level of urgency during maintenance time.					
xix.	There is no adequate training that would help artisans/technicians increase their level of understanding about the machines.					
xx.	The management doesn't give enough attention to training of the manpower to improve the technician capabilities.					
xxi.	There is no performance based maintenance rewards and incentive systems.					
xxii.	The reporting hierarchy is less convenient to bring about the maintenance and production improvement.					
xxiii.	The maintenance and production management team has inadequate understanding of the machines to be maintained and technical knowhow.					
Part II. Maintenance Practice in EAB SC						
i.	EAB lacks a proper preventive maintenance philosophies and strategies to alleviate productivity problem.					
ii.	EAB does not have a well-established maintenance execution system.					
iii.	EAB lacks an autonomous maintenance system that involves and participates the operators.					
iv.	The company does not have an organized way of maintenance					

	controlling and follow up of the maintenance activities.					
v.	The company does not have the right procedure to controlling and following up of maintenance practices before, during and after maintenance is undertaking.					
vi.	The technicians do not refer documents and manuals of Manufacturers of the machines while doing maintenance activities.					
vii.	The technicians are not using advanced condition based monitoring such as oil analysis, vibration analysis, and Chemo graphic analysis to help them predict premature failures.					
viii.	EAB don’t have SOP (Standard operating procedure) for both maintenance and production activities to enhance productivity.					
ix.	EAB lacks a well-organized PM maintenance schedules and strategies to enhance the required productivities.					
x.	The company does not have a proper Maintenance work instruction while doing maintenance and there is guess work or try and error approach.					
xi.	The company have not got a clear guide line on how to perform and fix maintenance challenges and problems.					

Appendix II-Interview Questions

Part I: General Information

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

1. Educational background: Diploma ☐ First-degree☐ Second degree ☐
   Terminal degree, other (specify) ☐ ____________________________

2. Current Position category: Operator ☐ Technician/Artisan ☐ specialist ☐ technical management☐ production management☐ other (specify) _____________

3. Service year in EAC: years _____________

Part II. Dear participant, read the following questions carefully and provide valuable and relevant information to each of the questions

1. What does technicians current conditions look like in relation to maintenance practice working in the EAB SH.CO? What is their gut feeling towards maintenance?

   ………………………………………………………………………………..….

2. Since it is always expected, what are the Major challenges of maintenance in the four bottling lines that you have been facing has become an obstacle to achieve your production volume?

   ………………………………………………………………………………..

3. In your assumption, what are the major problems for not achieving your production goal? Why?

   ………………………………………………………………………………..

4. Taking the above question (Q. 2) in mind, what are the mechanisms that the company doing in order to cope up with the challenges of maintenance encountered at different times?

   ………………………………………………………………………..…….

5. Do you believe there is a schedule enough time (about 10% of production time) for maintenance undertakings? Why or why not?

   ………………………………………………………………………………

6. In your assumption, what are the key factors that influences the production performance?

   ………………………………………………………………………………

7. What do you expect artisans and operators do in order to improve the production of the equipment?

   ……………………………………………………………………………….

8. What are the criterion you use in order to measure maintenance practice of employees?

   …………………………………………………………………………….

9. Does Maintenance practice have any relation with the production performance? How?

   …………………………………………………………………………….

10. How do you see the maintenance management system of EAB SH.CO in general in relation to increasing your production performance?

    ………………………………………………………………………………

11. What is your reaction to the idea “management believes that PROPER MAINTENANCE PRACTICE is unnecessary since THE MACHINE CAN RUN UNTIL IT FAILS, RUN TO FAILURE MAINENANCE”?

…………………………………………………………………………………….

Comments if any

……………………………………………………………………………………………

The End.