ST. MARY'S UNIVERSITY SCHOOL OF GRADUATE STUDIES

ASSESSING PRACTICES AND CHALLENGES of BREAKDOWN MAINTENANCE PROJECT WORKS AND ITS EFFECT ON PRODUCTIVITY: CASE STUDY on EAST AFRICA BOTTLING S.C. of Addis Ababa Plant

BY MELESSE ABATE (ID: SGS/0317/2014A)

A THESIS SUBMITTED IN PARTIAL FULLFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE IN MASTER OF PROJECT MANAGEMENT OF THE UNIVERSITY OF SAINT MARRY'S.

ADVISOR: DEJENE MAMO (PHD)

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APPROVED BY BOARD OF EXAMINERS

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Advisor	Signature
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External Examiner	Signature
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Internal Examiner	Signature

DECLARATION

I, the undersigned, declare that this thesis is my original work, prepared under the guidance of Dejene Mamo (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.

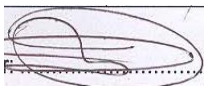
Melesse Abate _____

Name Signature

St. Mary's University, Addis Ababa June, 2023

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. Dejene Mamo signature

(Advisor name)

St. Mary's University, Addis Ababa June, 2023

DEDICATION

I dedicate this thesis to my son Nathan Melesse who gave my life a meaning and given to me as a blessing from God.

ACKNOWLEDGEMENTS

I am extremely grateful to God for the courage and strength He has given me in this academic journey and in my day-to-day life. Words cannot express my gratitude to my advisor Dr. Dejene Mamo for his support and guidance. My friends who have shared their advice have credit in the final output of this paper. My friends, I am also thankful for the times we have passed together in the program. It would have been just impossible without the support of my family and colloquies at East Africa Bottling S.C.

I am also extremely grateful for the financial support my company East Africa Bottling has provided to complete the program.

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List of Acronyms and Abbreviations

BD – Breakdown

CBM – Condition Based Maintenance

CM – Corrective Maintenance

CIP – Cleaning In Place

EABSC – East Africa Bottling Share Company

FMS – Flexible Maintenance System

KPI – Key Performance Indicators

ME – Mechanical Efficiency

OEE – Overall Equipment Effectiveness

PET – Polyethylene terephthalate

PM – Preventive Maintenance

RCA – Root Cause Analysis

SAP – System Applications Program

SPSS – Statistical Package for Social Sciences

USD – United States Dollar

USLE – Uninterrupted System Line Efficiency

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Abstract

Breakdown maintenance management needs attention and strategic approach as it happens without plan. in this study, due to equipment breakdown alone the company has lost a volume of 1.5Million cases of product in 2021 a revenue of 450Million birr has been lost. Most of the breakdowns happen several times indicating there was lack attention to detail to the nature of breakdown. Descriptive research has been used and a mixed approach of data collection has been utilized to conduct the study. The population size was 33 and a census of the population was used. Maintenance of equipment assures the sustainability of productivity in a manufacturing facility. Corporate companies like East Africa Bottling requires well-structured and organized maintenance team to meet the business goals at large. Related with productivity and efficiency of production lines, making sure the equipment within the production lines maintenance be made properly executed. There are several factors which affect the availability of lines to sustain it productivity. One of the factors that affect the availability of a production line is breakdown of machinery. In this paper, the effect of equipment breakdown on plant productivity done on Addis Ababa plant of East Africa Bottling has been analyzed. In the analysis several equipment breakdowns have been seen to be redundant and the 5% breakdown standard has not been met though the set standard were to meet an equipment breakdown of less than 5%. Using qualitative and quantitative methods the challenges of maintenance practice has been assessed. Some of the challenges include proper tool provision, lack of proper information sharing between maintenance teams, training provision based on the technical skill gaps and information acquisition of past breakdowns and cost of breakdown has been challenging. Having an experience of more than 20 years in the beverage industry in Ethiopia, the company has rich potential in maintaining equipment breakdowns and could be bigger source of expat to export skilled manpower to group member companies in other African countries and be source of foreign currency for the country and the company by organizing the maintenance practice and manage the maintenance operation.

Key words: productivity, maintenance, breakdown maintenance, breakdown standards

CHAPTER ONE

1.1 Background of the Study

In today's competitive world, productivity is becoming a key to success. In any corporate business, there is a breakeven point above which point ascertains the health of the business being better. In this regard, productivity, and efficiency of a manufacturing firm process helps to attain the breakeven point in a better way and guaranty profitability of the firm. Hence, working on things which improve productivity and efficiency is important to maximize profit of a business.

The manufacturers around the world are working harder to effectively utilize their competitive advantages to maximize their share in the market. Working to improve productivity and efficiency, which is one of the major competitive advantages for manufacturers, helps to the reduction of total cost/unit, and this should be the primary goal in any productivity management process in effect profits can be made not by random price increases (which causes price inflation) but rather by holding the prices at current levels or even decreasing them to increase market share and lead the market (Mifta J., 2010).

The bottling of beverages industry like that of East Africa Bottling is a standard product manufacturing firm where its products are made in mass production business strategy. One of the areas of improving productivity could be to maximize the availability of the production lines through assuring supply of raw materials and inputs and reducing downtime of machineries by properly doing maintenance. Equipment breakdown or down time is the time when the machine or system is not delivering what was supposed to deliver. Machine downtime has been defined as the time at which the machine is not in a condition to produce output. It can be planned or unplanned (Kolte & Dabade, 2017). By planned downtime it means the machinery has been set to be down intentionally for maintenance or inventory or other reasons. Whereas unplanned downtime is the sudden stoppage and loss of output from the machine under consideration. The focus of this paper is to assess the actions taken to address unplanned downtime and the challenges the maintenance team has faced, and the effect unplanned down time possess on the overall business productivity of the plant.

Equipment can be down due to several reasons; like due to lack of raw material, shortage of sufficient warehouse for storage, due to downing of sales and other factors. In this paper the

researcher focuses to assess factors contributing to equipment breakdown beyond the target 5% standard. Having good maintenance system leads to efficiency, on time delivery, customer satisfaction and higher quality (Kumar and Rudramuthy, 2013). Maintenance management requires proper analysis and planning in a situation where the availability of the machine is demanding. One of the reasons working on breakdown management in machineries leads to proper utilization of time as a resource and hence improve the efficiency of the equipment.

Maintenance of any kind require proper resource allocation, technical skill, problem solving skill, communication skill and utilizing information, importing knowledge, and organizing and managing all these for effective maintenance is required. Resource includes spare parts, human capital and time are needed. To meet the business plans of the company, the yearly production plan is cascaded to quarterly, monthly, to weekly and then to daily plans. To achieve the above plans, the role of the maintenance team is critical by ensuring the reliability and availability of the equipment in the process of product producing. The maintenance team conducts preventive and corrective maintenance by properly planning the maintenance of equipment with the standard to achieve a 5% breakdown or lower with the resources allocated one of which is the skilled technical team of the maintenance department. However, the utilization of the skilled manpower has to be in a way to improve the machine availability and hence promote productivity.

The cost of maintenance is estimated to be between 10 - 25% of the total operating cost. To reduce this cost, a systematic approach in maintenance would significantly diminish it. On the other hand, more than 50% of maintenance cost is labor cost. In addition, increasing the efficiency of maintenance would positively impact the reliability of the equipment also inefficiency of maintenance is noticed most of the time which lead to cost to be incurred and reduce the profitability of the company (Close T, et.al, 2012). As it has been sited on AiSight's website from international journal of Production Economics, maintenance cost can take 15-40% of production costs (Löfsten, 2000). Most authors suggest preventive maintenance would reduce unplanned equipment breakdown hence increase maintenance efficiency (AiSight, 2022).

It's true that preventive maintenance contributes largely to equipment reliability and reduce unplanned breakdown. But the core of this paper is when a breakdown happens how to respond with minimum amount of time, and device means by which one can maximize the equipment

availability and productivity by reducing machine breakdown. Breakdowns consist of several features; longer changeover time, lack of raw material, lack of manpower for production and others contribute to equipment breakdown. Lean changeover is not only changing parts fast but avoiding waste during changeover (Henry J, 2013)

Even though, the target is to attain 5% and below equipment breakdown, practically it is not happening due to different reasons. One of the reasons is on time delivery of resources like spare part due the country's foreign currency shortage. As a result, greater equipment breakdown is registered to replace the original failed part with modified one or a secondary damage made by failing to replace on time a failed component. The other reason could be effective preventive maintenance as per the manufacturer's recommendation is important. This is done through preventive maintenance tasks like running checklists, lubricating, tightening and replacing on time as per manufacturer's recommendation helps to avoid sudden and unplanned breakdowns.

The practice being used is to fix breakdowns and do RCA to identify the root cause of the problem and follow for six months if the solution given and the root cause identified is correct. The RCA is done on paper based which makes it difficult to use as a reference and take lessons what has been done previously on the equipment. In case an exact the same problem happens some two months ago on same equipment by other artisan, it will not be easily referred and use the type of solution by the current artisan who is working on the issue. Sometimes the simple solution takes longer time to fix because of lack of information.

Breakdown is an expensive operation in that it leads to loss of product and expense for the people working to fix the breakdown. In addition, the parts replaced due to wrong removal of parts from the equipment are regarded as loss for the company. The artisans who are brought from their leave create a stress and reduce the motivation to go to work.

1.2 Introduction to the study

In any manufacturing process, inputs like raw materials, human resource, information, energy and financial are converted to product or output. The conversion rate is termed as productivity. Hence, increasing or improving productivity means improving the output for the same amount of input in each manufacturing process. Together with efficiency, manufacturing cost and revenue, manufacturing productivity one can determine the overall company success. In this regard, the effect of maintenance in the overall productivity of East Africa Bottling Addis Ababa plant has been assessed.

The soft drink production process consists of several processes beginning with water treatment to final filling and packing of the product for sale. In all this process, there are several equipment or machinery involvements to get a quality product from the production line. These processes consist of several machinery working together as a system to meet the objectives of producing quality product to the customer.

The company's goal highly depends on the reliability and availability of the equipment working in the production line as well as supporting equipment in the process of beverage production. Hence, the maintenance and availability of the equipment is key for the success of the company. To maintain the reliability and availability of the equipment, a great deal of resource is allocated including skilled manpower from local and abroad is utilized, state of the art technology, capital investment and product development to state some. To monitor the level of equipment availability and reliability, a 5% equipment breakdown has been set by the company across all plants in the country. However, due to different reasons the set standard of breakdown is challenging to be met. The breakdown standard is set as a target for all production lines. And a 1.5% equipment breakdown is set for utility and process area machineries.

As a means of measuring the performance of the maintenance team, different Key Performance Indicator (KPI) has been set and tracked every month to review the success and challenges of the maintenance team. One of the KPI is equipment breakdown. Breakdown is calculated by dividing the machine lost hour by total man hour of the plant. Breakdown is set by the lowest machine capacity of the production line in a V- profile arrangement. In the production set up of the plant, the filler is the lowest capacity when measured per an hour operation. Hence, a breakdown is registered if the filler is unable to produce due to different reasons. Anything which causes the

filler to stop or unable to produce is termed as a line breakdown. If a filler stops for more than 10 minutes, the artisan who is working on the respective line will report to its maintenance controller and after it is fixed, the artisan together with equipment operator will conduct a Root Cause Analysis (RCA) to identify what caused the line to stop. The RCA is then captured on System Application Program (SAP) as history of the equipment to use for different planning analysis.

Equipment breakdown is related directly and indirectly to performance of production line and the company's goals in general. One of the relations with equipment breakdown is with Uninterrupted System Line Efficiency (USLE). USLE is the measure of how the production line perform without stopping. So, one of the factors which affect the value of USLE is breakdown as the line will not produce when a breakdown happens. On the other hand, if the line could not produce, the production line will not meet their goals. Cumulatively, the equipment breakdown affects the overall performance of the company by impacting the line efficiency. The other KPI related directly with equipment breakdown is machine efficiency (ME). ME is the percentage the production line was effective or efficient with respect to the production plan. So, if the line could not produce due to breakdown, it will not meet its plans and will affect the ME of the line.

The researcher has used descriptive method to assess the facts in the shop floor of the plant. To get the facts about the effect of breakdown maintenance on the productivity of the plant, a mixed type of approach has been utilized where the qualitative approach has been conducted by interviewing mechanical and electrical specialist teams and the quantitative approach of data collection has been applied via questionnaire and analysis of secondary data extracted from SAP system.

Maintenance of machinery in process industry can be generally categorized in to two broad branches: preventive or planned maintenance and corrective or unplanned maintenance. There are subdivisions in both types of maintenance. The focus of this paper is on the corrective maintenance approach in Addis Ababa plant. Equipment downtime or breakdown can happen due to internal and external factors to state some: lack of raw material, lack of storage, lack of demand in the market and equipment breakdown. The focus of this paper is to assess the equipment downtime due to equipment breakdown maintenance which is internal cause and within the capability of the plant. As the unplanned maintenance is conducted without being planned about the breakdown, it needs special maintenance management to optimize the availability of the equipment. One of the

main challenges of maintaining the set standard of 5% breakdown was due to lack of proper breakdown maintenance management in the plant. In this paper the researcher has assessed the factors contributing to make the breakdown percentage time out of the set standard in Addis Ababa plant taking the plant as a sample and project it to other plants operational by East Africa Bottling S.C.

As the company has been in the business of beverage production over 20 years in Ethiopia, there are several knowledge and skill developments within the team. and the type of breakdown which has happened are most of them are repeated in different time periods; and there are several learnings gained in the process of fixing the breakdowns at different times. Due to this, the gained experience of fixing breakdowns and the learning should have been compiled to make use of it for future challenges. Moreover, the maintenance management system within the plant has not been used effectively to manage breakdown maintenance on the other hand the preventive maintenance management has been managed properly by the SAP system. The data used for the analysis of this paper has been used for business year of 2021 and it has been found that 150million cases of glass products has been lost due to equipment breakdown alone in Addis Ababa plant. Even though, breakdown of an equipment is inevitable a significant amount could have been saved and generated revenue by effectively managing breakdowns.

The paper has five chapters. In chapter one the background, statement of the problem, objective of the study, significance of studying and its scope has been revealed. In chapter two the theoretical and empirical studies regarding maintenance and productivity relationships and breakdown maintenance effects on productivity have been reviewed. In chapter three the methodology utilized to approach the research problem and data collection techniques have been stated. In chapter four the collected data has been analyzed and the outcomes has been interpreted. In the final chapter of the paper the conclusion and recommendation regarding the findings has been outlined and possible future research areas in also been stated.

1.3 Statement of the Problem

In this paper, the researcher has attempted to address the effect of breakdown maintenance on the productivity of production lines by assessing the practice of breakdown maintenance in Addis Ababa plant of East Africa Bottling S.C. as case and use the approach to cascade it toother similar manufacturing facilities in the country or elsewhere. Breakdown maintenance takes away many resources from the business. When a production line stops due to a breakdown on one of the machines in the process, it takes the time used for production of the line and impacts the business losing the product that need to be delivered to its customers, the company will lose some of the raw materials in the process of to be changed to product and impacts the morale of employees working in the production line.

One of the main KPIs of the maintenance team is to attain 5% and below equipment breakdown per line and maximize the equipment availability. Preventive maintenance is done with the assistance of SAP system which periodically retrieve checklists for artisans to execute preventive maintenance tasks. Although there is a question of preventive maintenance effectiveness, the main concern of this paper is to assess the causes of breakdown percentage greater than the set target value. As breakdown maintenance is expensive as compared to preventive maintenance, dealing about it systematically is important.

From time to time the performance of the Addis Ababa plant is not consistent and both the production team and maintenance team has been straggling to meet daily, weekly monthly, quarterly, and yearly production plans. The source of the challenge could be several; internal and external. In this paper I will be discussing challenges related to internal issues and which could be handled by the maintenance team.

As unplanned equipment breakdown is inevitable, the 5% breakdown from the available time of production is set as a target. As being in the business for more than 60 years, the nature of the breakdown is repetitive. However, the understanding between the technicians is not close. The gap in the skill difference between technicians contributed a lot in the difficulty of attaining the 5% equipment breakdown target. As a result, the business productivity and profitability become at risk which could been addressed systematically and attain business goals finally.

As a guideline, any breakdown which lasted more than 10 minutes a Root Cause Analysis is required and the technicians and operators and other member of the maintenance team who involved in the fixing of the breakdown is going to do the RCA and identify the root cause of the breakdown. Then the RCA is captured in SAP system for future reference and as a history of the equipment breakdown. One of the uses of the RCA is to identify the focus area after analyzing the breakdown trend in the production line. However, the RCA is done on paper based with a carbon copy and the original is sent to data capture the carbon copy remains on the RCA pad with the technician. The problem lies it is difficult to refer the type of solution given previously on similar breakdowns happened. The breakdown captured on SAP is not accessible by the technicians which makes it difficult to learn from experience.

Every production line has three shifts. But the skills of the artisans working at different shifts and working for the same shift is not the same. However, all artisans task is the same. This contributed to the inconsistency of breakdowns on shift bases. Because of the different understanding level, a minor problem could take longer time to fix, and a support of a specialist is required to come from home and fix it which until the specialist reaches the plant took time and contributed to the breakdown time to be longer by the time the job gets done.

1.4 Objectives of the Study

1.4.1 General Objective

To assess breakdown scores of production lines in Addis Ababa Plant against the target breakdown stand of the plant and analyze the effect equipment breakdown has on plant productivity and also assess factors contributing to the variability in breakdown values from time to time.

1.4.2 Specific Objectives

- To assess the breakdown percentage of business year 2021 for all the production lines in the plant
- To analyze the production volume lost and the contribution each machinery has in the year 2021.
- To assess and analyze what factors has contributed to the breakdowns.
- To compile breakdown reduction strategies which could help improve the productivity of the plant from the findings.

1.5 Research Questions

The research aims to answer the following question through data collection of primary and secondary data with the base of 2021 business performance and the challenges seen in that specific year at Addis Ababa plant.

- How have equipment breakdown affected in meeting the production plan in Addis Ababa plant?
- Which machineries contributed to the volume loss in the business year 2021 and the type of breakdowns that has happened?
- What competitive advantages and draw back are there to sustain the productivity of the plant and how can be used as a model for other similar plants within the company and other similar manufacturing firms in the country?
- How could previous challenges be a learning for future business plan accomplishments?

1.6 Significance of the Study

Equipment availability is the key in the manufacturing business; because in manufacturing inputs are processed in to output with the help of machineries and people operating and working in the process. Hence, by reducing the machinery breakdown would help the company produce the planned volume and delivery to customers on time and secure customer loyalty. In so doing increase the revenue of the company and hence its profitability.

One of the benefits that a machine breakdown provide could be that it will create a window of opportunity for the maintenance team and operators to learn and think critically about the equipment in question. Therefore, in the process of fixing the breakdown helps the team learn and do it in a better way when the problem happens for the second time. So, by sharing the learnings gained in each challenge serve as a source of awareness for other shifts working on the same line and other teams working in similar equipment.

The loss of unplanned breakdown is huge. To put it in simpler terms, if every line in the plant stops per day for an hour due to a breakdown the company will lose a production of 120,000 glass bottles of product and 36,000 plastic bottles. Therefore, working to reduce unplanned equipment breakdown is critical for the productivity and hence the profitability which help to meet the bigger company goals, and vision at large.

In the process of productivity improvement, all aspects of the process will take time to reach the level of productivity required. In this thesis project the breakdown effects on the productivity of the plant have been dealt. Due to equipment breakdown, East Africa Bottling S.C. Addis Ababa has lost 1.5Million cases of product from the glass lines only. With the recommendations and the findings in this thesis, the plant would work on the findings and improve the productivity and could be used for other plants in the country and abroad within the group. Moreover, as the manufacturing sector process is similar, the finding can be used to improve the equipment breakdown and improve the productivity in a similar fashion.

By implementing the recommendations on this paper would help the company and other similar firms to save a lot of resource like the money invested to import experts from other country and helps to raise the technical skill level of employees through idea and information sharing in a better

way. Further, in the long term would help the country at large in exporting skilled manpower, expats, to neighboring countries and other parts of the world.

1.7 Scope and Limitations of the Study

1.7.1 Scope of the Study

The thesis focuses on the maintenance practice and breakdown maintenance activities. Of the five plants EABSC operates, my focus is on Addis Ababa plant. However, the findings can be applied with proper context on other plants of the company. As the other plants are working on similar set up and structure, this study can be used as a model for other plants of the company. The machineries considered in this plant have similar working principle or are the same in some plants.

The thesis only considers down time due to machine down time which are internal to the company and did not consider external causes of downtime like raw material shortage or logistic related issues. The study covers the 2021 business year scenario.

1.7.2 Limitations of the Study

As a limitation, the thesis is not going to address other EABSC plants. Due to the other plants are geographically dispersed, it will be difficult to address and investigate the breakdown problems and their good practice. Also, operators who don’t involve in breakdown activity are not part of this research as their role in breakdown maintenance is minimal.

In this research the breakdown aspect of the plant KPI or line KPI is considered. Each KPI has its own depth to be analyzed and researched. Because of the great and key impact, it has on operational performance of the production lines, I choose to investigate equipment breakdown and did not describe the relationship of breakdown with other line KPIs.

CHAPTER TWO

Literature Review

2.1 Theoretical Background

Project is collection of interrelated tasks which are unique, with specific beginning and ending time, executed by a person or organization to achieve a specific objective within defined schedule, cost and set standards. Project management techniques have been utilized by several manufacturing firms, commercial organizations, and financial institutions to meet their business goals and objectives (Lester A, 2006). In this regard, one of the project areas the researcher identified was to assess the contribution of breakdown maintenance effect on the productivity of the plant.

Business survival of a manufacturing company depends on its ability to compete effectively. The structure of manufacturing company has shifted from labor intensive to capital or technology intensive (Alsyouf, 2007). To sustain the survival and profitability of the company, maintenance function improvement is important because it plays a great role in improving the availability, delivery of quality product, performance efficiency, total cost effectiveness, on time deliveries and environmental & safety requirements (Al-Najjar, 2000).

Maintenance of equipment is indispensable in every manufacturing process industry. This is because efficiency and quality of product being manufactured decreases unless proper maintenance is in place and equipment in the manufacturing process may fail more often over time if it run without the required maintenance impacting productivity of the firm (Mehmeti Xh., et.al, 2018). Maintenance management ensures firm's asset productivity enormously. However, the focus given to maintenance is minimal. On the other hand, the cost related to maintenance is about 15-40% of the production cost depending on the manufacturing industry which can significantly affect profitability of the manufacturing industry (Tran Van Tung, 2009). This signals that maintenance play a key role in the overall productivity of a firm by keeping the equipment in a state of good working condition and takes significant share of cost of production therefore impacting the profitability of the firm.

The main goal of both the production team and maintenance team is to achieve production plan and maximize productivity. This can be done with the strategies to reduce the equipment

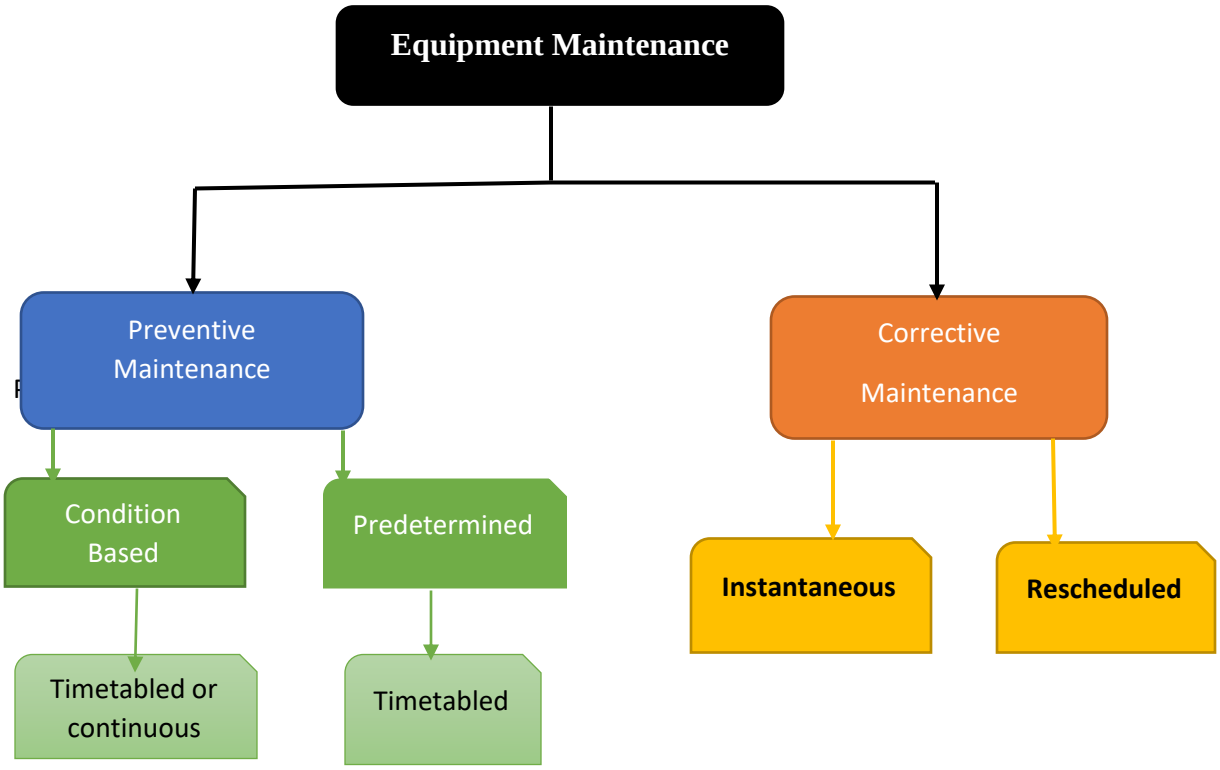
breakdown and maintain smooth operation of the equipment. As productivity is the ratio of production output to the inputs which include raw material, capital, energy, manpower and the like, if production output is smaller than expected it will affect overall manufacturing efficiency or Overall Equipment Efficiency which deals with the measures of utilization, yield, and efficiency of the process (Shagluf A., 2014; Okpala O., et al, 2021). Therefore, to maximize production output, maximize profitability and improve plant productivity, equipment availability is a key.

Automation and mechanizations like Just In Time (JIT), Flexible Manufacturing System (FMS), robots systems in current manufacturing practice required availability of equipment for production is becoming critical due to the fact that breakdown affects production volume and quality of product to be produced. (Alsyouf, 2004; Al-Najjar, 2007; Wireman, 1990 as sited by Martyn O. and Aimienrovbiye G., 2010). With different level of sophistication, maintenance of assets, equipment and property is the unavoidable aspect in running a business. However, the maintenance of equipment is not to keep it running forever; it will help to run smooth and efficient. As a natural wear and tear the equipment malfunction, fail, or slow down over time. due to natural wear and tear (Wu W., 2020)

Maintenance can be broadly defined as the combination of all technical, managerial, and administrative actions done during the life cycle of an item designed to retain it in or restore it to, a state in which it can perform the required function (Rastegari A., and Salonen A., 2013). In general terms, maintenance of equipment can be categorized in to two broad area as Preventive and Reactive maintenance. Preventive maintenance is the precautionary actions taken to prevent the equipment from failure. It helps to minimize equipment breakdown and business closure due to the unexpected breakdown of equipment, increase essential assets and equipment life expectancy and lower the energy consumption of equipment and reduce operation cost of the business energy bill (Wu W., 2020). The other category of maintenance is reactive type of maintenance where it is applied when the equipment has already failed to operate or called run to failure kind of maintenance approach. It may or may not be forecasted that the breakdown is happening. The challenges related to this kind of maintenance is that if a breakdown on an equipment happens the whole production line stops and the firm loses revenue, creates lack of trust with customers expecting delivery of firm's products and hear the bad news (Immerman G., 2020). And often maintenance of machineries in production firms is considered as a secondary process

due to lack of management attention (Ashayeri J., and Teelen A., 2014). The focus of this paper was on how to mitigate the frequency of unplanned maintenance and assess the causes of unexpected equipment breakdown in East Africa Bottling Share Company Addis Ababa plant.

Figure 2.1 Types of Maintenance



(Source : CEN, 2001)

Corrective maintenance was no longer enough to satisfy industrial maintenance requirements, such as reduction of failures and degradations of manufacturing systems to the greatest possible extent (Lemelem D., 2018). These days the definition of maintenance has changed from its traditional definition of repairing when it fails to a new thinking which increase the availability of the machine an approach called proactive approach or preventive maintenance concept. For this the strategy Condition Based Monitoring has evolved to support preventive maintenance approach. CBM is different maintenance activities which show the real-time or near real-time assessment of equipment conditions using CBM tools, which is obtained from embedded sensors and/or external tests and measurements. The measurement can be taken from a portable equipment and/or subjective condition monitoring tool. CBM is increasingly recognized as the most efficient strategy

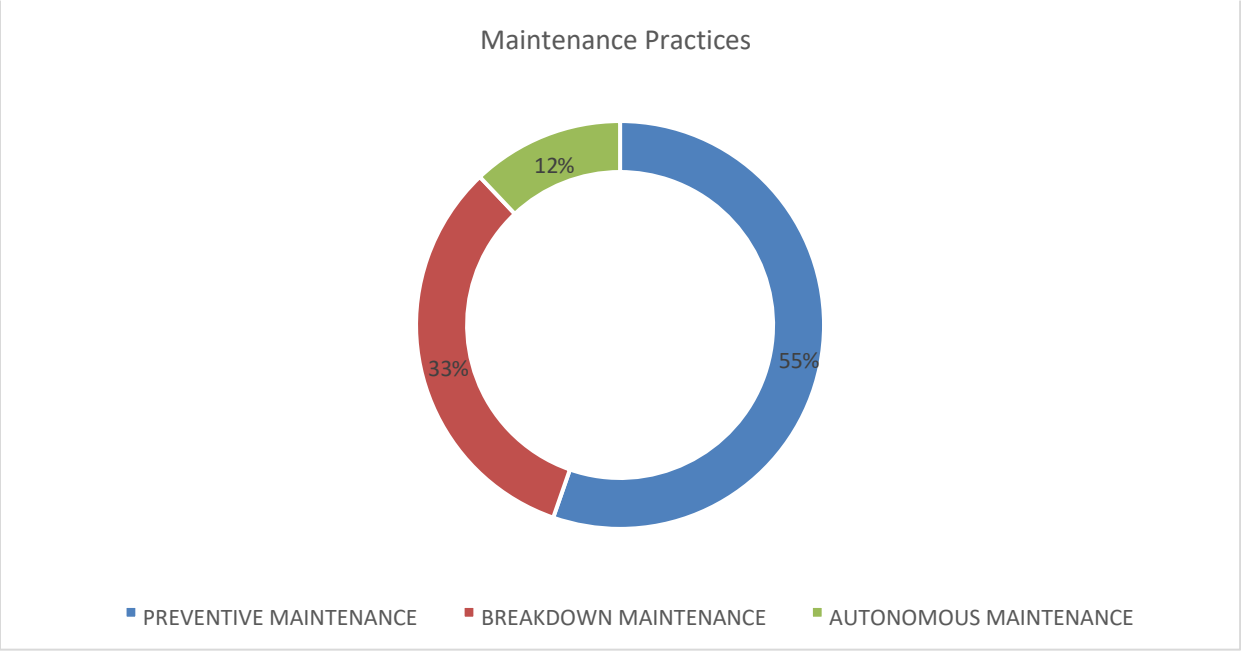
for performing maintenance in a wide variety of industries. However, the practical implementation of advanced maintenance technologies, such as CBM, is relatively limited in the manufacturing industry (Rastegari A., 2017).

As it has been stated earlier, the practice of effective maintenance believed to be executing preventive maintenance properly. However, the nature of breakdown maintenance is not predictable and need practical experience to figure it out and fix it. Companies like EABSC have vast experience in the bottling sector and have developed several skills from the breakdowns and other maintenance types taking place in the different plant. This skill is a treasure for the company and need to be well organized to use for the best of the company and play in making the plant and the company profitable. The major thematic area of this thesis is on business development ideas and how the knowledge management would contribute to the sustainable development and profitability through raising the productivity of the plant in question and other similar plants within the country and abroad.

2.2 Empirical Background of the Study

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 (Corrective maintenance). A proper implementation of planned maintenance strategies results in reduced maintenance cost and reduction 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 since the breakdown of the machine failure is relatively the same as the planned maintenance undertaken in the company (Lemlem D., 2018). Actual distribution of Maintenance Practices followed by EABSC Source: EABSC SAP System (Year 2015-2017).

Figure 2.2 Maintenance time share in type in EABSC plants



(Source: SAP 2017, EABSC)

Investing on maintenance execution might seem a cost to the firm at the initial stage of implementation as it is hard to measure and follow up its impact on company's business. However, its role in improving company productivity and profitability is indispensable. Therefore, maintenance is a profit center rather than a cost center (Enofe M. and Aimiennovbiye G., 2010). Manufacturing companies' performance and competitiveness depend on the reliability, productivity, and availability of their production facilities. To ensure that the plant reaches the desired goals, maintenance managers need a good performance track on the process of maintenance and maintenance results (Er-Ratby and Mabrouki, 2018).

To remain competitive, manufacturing industries should consistently raise the effectiveness and efficiency of their production processes. After the introduction of lean manufacturing process, concerns about equipment availability and, therefore, the demand for effective maintenance has increased. Hence, maintenance become more important for the manufacturing industry can be evident in current discussions on national industrialization agendas. Even though, there has been increasing desire for reliable production equipment, only few manufacturing companies pursue the development of strategic maintenance (Rastegari, 2017). The researcher has stated further that maintenance strategies are influenced by frequency of breakdowns, downtime, and cost of repair.

These factors were used in maintenance decision-making models to enhance decision-making capability for a maintenance management system. Condition Based Monitoring (CBM) has been found effective for the sustainability and effectiveness of the maintenance practice (Rastegari, 2017).

Assuring the performance of individual machine tools is important to avoid expensive rework or scrap, with the critical impact this has on rate of product output (Shagluf A., et. Al, 2014). In manufacturing of products, output quality problem can be derived from several factors like machine tool on which the part has been manufactured. And the performance of the machine tool or group of these machines depends on design, layout, and operation as well as on effective maintenance practice and calibration during the operational life of the machines.

Maintenance is a strategic concern in high value manufacturing. To achieve an optimal, cost-effective maintenance approach, the analysis of failures and development and use of applicable mathematical cost algorithms is essential. The performance of a machine tool or group of machine tools depends not only on the design, layout, and operation, but also on effective calibration and maintenance of the machines during their operational lifetime. Other factors like operational related problems, poor measuring techniques, inaccuracy of the measuring tool and wrong interpretation of the collected data can be mentioned. Products scrapped due to above mentioned problems lead to raw material waste, loss of energy and consumables in the process of rework to correct the problem and all have a significant cost and negative impact on the environment. To help in reducing the above challenges, Predictive calibration technique is utilized to facilitate and controlled manufacturing accuracy related issues and investigate the causes of out of standard products. In so doing, the manufacturing firm can reduce machine tool downtime and easily trace the machine which caused the defective product and finally helps to improve overall efficiency of the facility (Shagluf A., et. Al, 2014).

A study done on Swedish paper mill showed that, annually 975,000 USD could be saved if the maintenance management of unplanned machine stoppage is avoided. Therefore, maintenance can be a profit generating function rather than a cost center. In manufacturing process, effective maintenance policy through its direct impact on quality of product, efficiency and effectiveness of operation enables the decision-maker to analyze the productivity and profitability of the firm. (Alsyouf A., 2004).

Maintenance activity in general can increase company overall productivity if carried out properly and regularly (M Mendez and Rodreriguez, 2017). An analysis done on Food Seasoning Industry showed that if performance of preventive maintenance is improved, the production output will increase. On the other hand, if breakdown maintenance cost increase, it will negatively impact production output (Setianwan I., 2021)

Knowing why a particular equipment created a breakdown helps to make decision, for instance, a chilled water problem for production has been solved with a purchase of new chiller and lack of air in the plant has been solved with the modification work done without a purchase of new compressor. In the study, the author concluded that the effects of maintenance on the productivity of the factory of disposable cups are relevant and direct. And the importance and criticality of time as a resource has been seen in the study; every second production loss is a lot of money loss in the final revenue and consequently the financial results of the organization. This can be shown if the plant stops for a minute, the organization will be liable to a loss of $ 33.60 and if it stops for an hour, it will lose $2,016.00 in revenue. The above analysis has been done for one machine and duplicating the effect on other machines shows that maintenance can improve the productivity of any industrial company as it reduces the machine stop and extends the life of the equipment (Duarte T., et.al, 2015).

Breakdown of equipment is inevitable no matter the type of equipment and disruption of operation. Hence, the possibility of breakdown needs to be considered during activity scheduling for production and capacity planning. In a case study conducted in Cussons Soap Manufacturing plant, the researcher found out that due to high demand of the company's product, there has been several equipment breakdowns and plant shutdowns because the plant has been running for 24 hour a day and seven days a week with 'a run to failure' maintenance policy. The plant performance was found to be 64% against its potential production capacity and lost a 36% production capacity revenue which was around 3.24Millio Euros annually due to lack of proper maintenance policy (Tanwari A., et.al, 2009). And a strategic maintenance plan has been suggested by the researcher: "special care and regular monitoring of the plant is essential to reduce the costly breakdowns".

2.3 Research Gap Analysis

In the empirical literature review the effect of breakdown maintenance and effect of proper maintenance strategy in general on the productivity and profitability of a manufacturing firm has been discussed. According to the researchers, breakdown of machineries leads to raw material and quality product loss. To mitigate unplanned breakdown or stoppage of machineries, working on preventive maintenance and applying condition-based monitoring (CBM) on machineries has been suggested by several researchers. As breakdown of equipment is unexpected in most cases, breakdown maintenance approach requires special and systematic maintenance to minimize the equipment downtime due to the breakdown and maximize equipment availability which lead to better productivity and yield better performance.

Two scholars who have conducted their research on East Africa Bottling S.C., Addis Ababa plant investigated the challenges of equipment maintenance and the relationship it has with plant productivity (Lemlem D., 2018) and productivity improvement through avoiding losses of different kind like machine downtime, speed loss, raw material loss and minor stopes (Araya T., 2018). The researchers conducted a general overview of maintenance on productivity. Whereas, in this paper the researcher analyzed the effect of equipment breakdown on productivity and ways by which breakdowns can be reduced by effectively utilizing internal capacity between maintenance team and developing information sharing platforms.

Loss of productivity has several reasons. To state some; lack of resource availability, inefficiency of production equipment, equipment downtime due unplanned breakdowns, loss of product due to poor quality and other factors. From the factors affecting productivity, equipment breakdown due to unplanned downtimes get minimized with a capable maintenance team within and outside of the production facility. Building the capacity of own maintenance team has several advantages. When the capability of the maintenance team is improved, the availability of equipment will be maximized by fixing the breakdown in a shorter period.

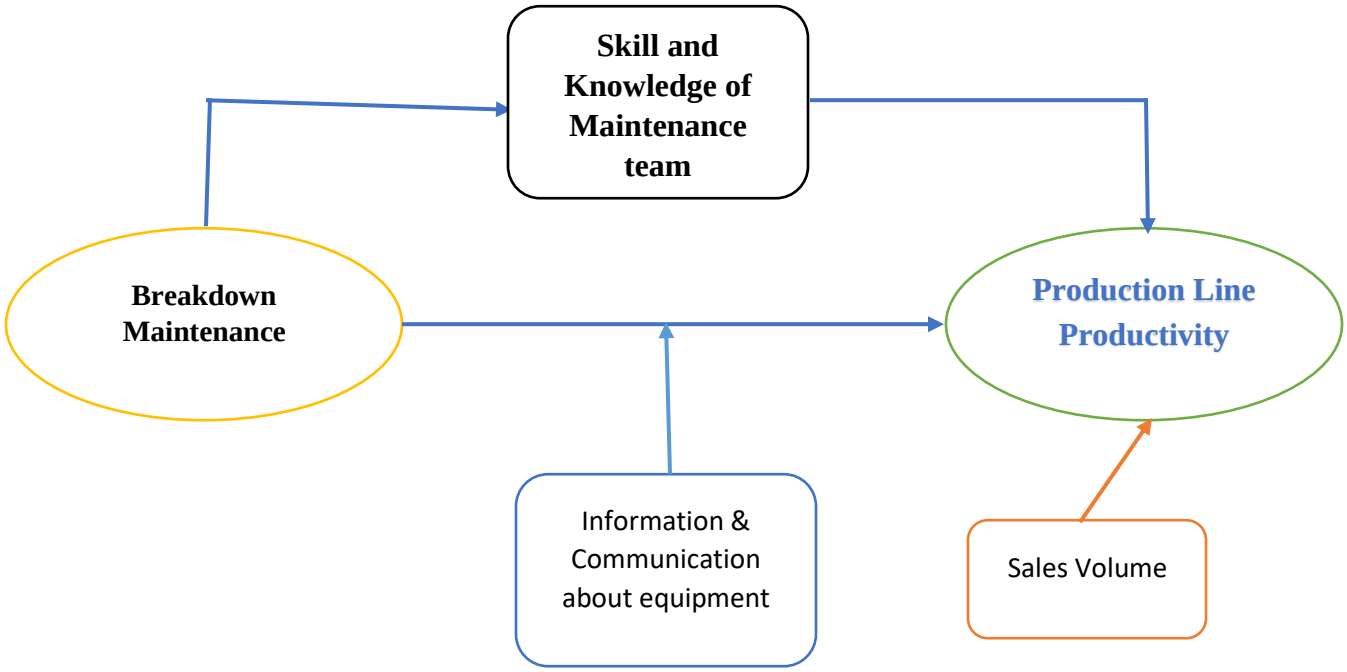
Research has not been done on equipment downtime and its effect on plant productivity in East Africa Bottling S.C so far. This paper analyzes the effect of equipment downtime in Addis Ababa plant by investigating the nature of downtimes and proposed possible solutions using qualitative

and quantitative methods. As the nature of manufacturing in Addis Ababa plant is similar to other plants of EABSC and other bottling companies like brewery plants and non-alcoholic bottling induststies, the outcomes of the research can be applied to other plants similarly.

2.4 Conceptual Framework of the Study

Maintenance has a significant effect on the productivity of a manufacturing facility. The main focus of the study is how to mitigate the effect of breakdown maintenance on the productivity of East Africa Bottling S.C. Addis Ababa plant as it is one of the internal factors affecting productivity and is under the control of the maintenance team. Addis Ababa plant being the oldest plant in the company with diverse and skillful maintenance team, the plant has bigger potential to be utilized for the improvement of breakdown maintenance.

Figure 2.3 Conceptual framework model



CHAPTER THREE

3.0 Research Design and Methodology

3.1 Research Design

Research is made of two things namely experience and logical reasoning to discover the truth (Igwenagu C., 2016). “Research is a creative & systematic work undertaken to increase the stock of knowledge, including knowledge of humans, culture and society, and the use of this stock of knowledge to devise new applications. It involves the collection, organization, and analysis of information to increase our understanding of a topic or issue” (Mitra A., 2021). Methodology provides theoretical concept for which method or different methods be applied to certain research (Igwenagu C., 2016). Similarly, objective of research methodology is to formulate and articulate strategies and methods by means of which the validity and credibility of research outcomes shall be maximized (Mouton J., 1996). The science and philosophy behind all research is the research methodology (Adams J., et al, 2007).

The main purpose of research methodology is to develop and articulate strategies and methods by means of which the validity and credibility or research results in the social sciences may be maximized.

The descriptive research approach is a basic research method that examines the situation, as it exists in its current state. Descriptive research involves identification of attributes of a particular phenomenon based on an observational basis, or the exploration of correlation between two or more phenomena.

Research design is a general strategy used to address research problem by integrating the elements of the research in a coherent and logical way in effect confirming that the research problem gets solved in an efficient way. It contains the game plan for the collection, data measurement, data analysis, result interpretation, and reporting of findings and conclusions (Kumar G. Vijay, 2015). A research design is plainly the framework or plan for a research study to be used in collecting and analyzing the data (Pandey P., Mishra P.,2015).

Data used for the analysis of the effect of breakdown maintenance on productivity of production lines has been collected. The researcher extracted data from SAP year 2021 breakdown records and causes of breakdown, how long it took and the consequences of the machinery breakdown resulting in loss of

production has been taken from the system. A production plan of the plant for the year 2021 were collected from planning office to compare the actual production with plan and investigate the contribution of machinery breakdown on the difference. A questionnaire has been designed and piloted on one of the production line maintenance team to check the reliability and validity of the instrument, questionnaire. The reliability and validity have been checked on SPSS and was found to be within allowable limits. To get more reliable and valid response, the questionnaire has been modified for distribution to collect responses from the rest of the respondents. The above data were used for the quantitative analysis of the research part.

For qualitative aspect of the research, an interview question has been prepared to be conducted on specialist team of the maintenance team. Both mechanical and electrical specialists were interviewed on the breakdown maintenance practice, the challenges and their views have been asked to improve ways working on breakdown maintenance. Specialists were chosen since they have been the ones who have participated and called for major and most breakdowns in the production facilities. Sometimes they have been sent to other plants for support and they have worked for more than ten years in the plant in different position within the maintenance department of the plant.

Microsoft Excel were used to analyze the data extracted from SAP system. The breakdowns were sorted based on the machinery breakdown and frequency and length of time the breakdown took and the volume of production lost were analyzed. The analysis helped to reveal the effect of breakdown on the business plan in the two business years selected for analysis. Questionnaires were analyzed on SPSS 20 version.

The interview with both specialists focused on the practice of breakdown maintenance and way forward in which the maintenance team improve maintenance approaches to achieve world class maintenance of 5% breakdown (White book SC matrix Rev23, p34). Their response has been presented on the analysis part of this thesis.

3.2 Research Approach

A mixed research approach of both qualitative and quantitative data analysis has been used to solve the research problem. The research has been conducted on a manufacturing plant in Addis Ababa where similar other plants of the same company are found in four cities of the country: namely in Dire Dawa, Bahir Dar, Ambo and Sebeta. Here Addis Ababa plant was taken as a sample and the findings could be applied on other plants as the nature of the business, beverage industry, is the same with the similar structure across the country. For this reason, an inferential approach research type was used from quantitative research approach: inferential approach type of quantitative approach is used to form a benchmark from which relationship or characteristics of population can be drawn (C.R. Kothari,2004).

Qualitative approach of interview has been conducted on mechanical specialists and electrical specialists who have worked more than ten years in the company who are supposed to have ample experience on breakdown maintenance and other maintenance works in the plant.

Induction approaches were used in that data were collected and analyzed then developed theory. The purpose of inductive approach was to get to know 'what has been going on' which helped to understand the problem better (Saunders M., et al, 2007).

3.3 Description of the study area

The research study has been conducted in a manufacturing facility of food and beverage industry. East Africa Bottling is sole bottler of Coca Cola products in Ethiopia. The manufacturing facility incorporates several machineries with chain of beverage ingredient processing processes. The beverage production lines are working in 24/7 set up which requires a proper maintenance facility. The maintenance team in all plants was organized in way to meet the daily, weekly and monthly plan of sales forecast and demand.

The study centered mainly on the day-to-day activities of the maintenance team with more focus on breakdown maintenance practice and approaches. The Addis Ababa production plant has similar with other production plants working in Ethiopia and designed to work in a similar working structure with other production facilities in other countries of the group, Coca Cola Beverages Africa Group. So findings in this thesis could be used in other plants operating in Ethiopia and outside the country were the business operates.

The Coca Cola bottling facility in Addis Ababa plant incorporates four production lines; three of them are glass lines and the other one is a PET line.

The main cause of this thesis work was observation while working as a maintenance team and living the problem with the whole manufacturing team as my capacity as a maintenance controller in the Utility section of the company. As a day-to-day routine of breakdown maintenance, we were in a circle of fixing downtimes thinking on the spot rather than learning from other shift team members who might have faced the issue before or otherwise sharing or experience of breakdown maintenance approaches to other maintenance team who could face the same problem in the future.

As can be seen on the data analysis and result section of this paper, different machinery breakdowns have been registered frequently reported taking different length of downtime. The time difference in solving the problem is an indication of lack of information sharing between the maintenance team or retrieving the information and use it to in fixing the problem in a reduced time and as a result increase the productivity of the production line.

3.4 Research Method

The thesis has been designed by collecting primary data and secondary data related with maintenance and specially breakdown maintenance. Using descriptive research method has been utilized as the researcher is describing the reality on the ground and analyze the good practice and the drawbacks of the breakdown maintenance in the case considered.

The research method has been organized by collecting primary data from questionnaire of employees working on the maintenance of production lines of the company, by interviewing specialists like mechanical specialists and electrical specialists who have ample experience and skill on the maintenance of machineries in the production lines. The secondary data has been collected from daily performance report extracted from the company's system called SAP. The secondary data was used to get a picture of how big the effect of breakdown maintenance on the company has lost had it been the breakdown was with in standard. For this the breakdown contribution of each machinery has been identified.

A questionnaire has been prepared to collect primary data from line technician, line (production line) electricians, mechanical specialists, electrical specialists, line process engineers, maintenance planners and maintenance controllers. The questionnaire has been piloted on one of the production

line maintenance team and process engineers and the reliability and validity of the questionnaire has been tested. Based on the test result a small correction has been made and the edited questionnaire has been distributed to the rest of maintenance team to collect the primary data.

Table 3.1: Cronbach's Alpha value of the pilot instrument

Construct/Group	Cronbach's Alpha values
Effect of BD on line productivity	**0.721**
Effect of BD maintenance on cost of operation	**0.746**
Effect of communication on BD maintenance	**0.817**

As all the values are greater than 0.7, the questionnaire is reliable to conduct the instrument to the main respondents. After the data has been collected with the tested and modified questionnaire, the reliability and validity of the instrument has been checked and found to be accepted as shown in the table below.

Table 3.2: Cronbach's Alpha value of the main instrument

Construct/Group of items	Cronbach's Alpha values
Effect of Breakdown on Line Productivity	0.861
Effect of Breakdown Maintenance on cost of operation	0.723
Effect of communication on Breakdown Maintenance time	0.717
Effect of Breakdown Maintenance on Quality of product produced	0.735

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.587
Bartlett's Test of Sphericity	Approx. Chi-Square	229.784
	df	120
	Sig.	.000

KMO value > 0.5 showing the questionnaires have moderate relationship among the groupings. And the validity has been checked for convergence and divergence and correlation is significant 1-tailed with 0.01 significance level.

3.6 Population of the Study

Population is the whole group about which your study would like to draw a conclusion from it (Brandari P., 2022). The focus of this thesis work is on one of the five plants East Africa Bottling S.C. operates, the Addis Ababa plant. As the main purpose of the study is to investigate the effect of machinery breakdown on business productivity, maintenance team were taken as population of the study. In the plant the maintenance team are thirty-three in number comprising of technicians, electricians, mechanical specialists, electrical specialists, maintenance controller and maintenance planners of all production lines. It is to be noted that the that the structure is similar in all other plants across the country where each production line will have three technicians, three electricians, i.e. each shift have one technician and electrician, a maintenance controller, a maintenance planner and use mechanical specialists and electrical specialists for all production lines where there are more than one production lines per plant and a mechanical specialist and an electrical specialist is assigned for a plant where there is one production line.

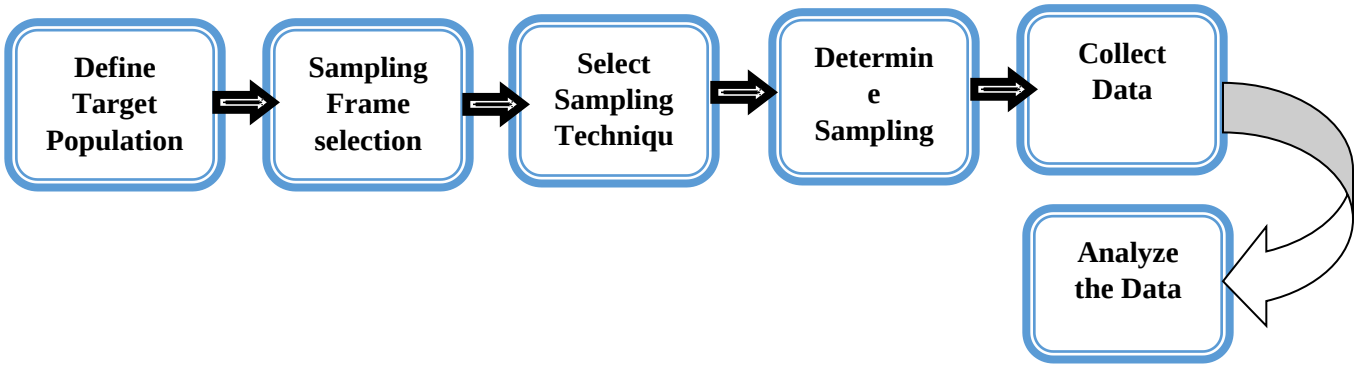
The maintenance team oversees the downtime of machinery in the production facility. In addition, the team's KPI (Key Performance Indicator) at the end of each business year or the revision period like in the middle of the business year was measured by the target set regarding machinery breakdown set as 5% as a target meeting below the target level would lead to a motivational rewarded by the manufacturing manager.

3.7 Sampling and Sampling Techniques

As the population size was thirty-three and which is manageable to collect data, the researcher decided to use census for the study. For manageable population size research question is possible to collect data (Saunders M., et al. 2009).

Population is constructed by members who meet a set of specifications or specified criterion. And a sample is taken from a population by selecting some of the members. On the other hand, when a researchers wanted to study all members of a population it is referred to as a census.

Figure 3.1: Sampling technique flow chart



According to the above sample selection from population, the population target has been defined as the maintenance team of Addis Ababa Plant in East Africa Bottling S.C. then the sampling frame was members of the maintenance team were listed out. As the number of the maintenance team in Addis Ababa plant was not big to handle the whole population in the research study, the researcher decided to use census rather than taking a sample for analysis. Finally, the designed questionnaire has been administered to the whole team of maintenance in the plant and collected for analysis.

3.8 Tools for Data Collection

Questionnaire and interview have been used to collect primary data from respondents who are members of the maintenance team in Addis Ababa plant. In addition, secondary data were collected by extracting production data from SAP and production plan and actual production volume have

been collected from planning office of the plant. Since the thesis have been conducted with a mixed type of research type both quantitative and qualitative data has been collected to meet the objectives of the research in answering the problem statements. The qualitative data has been collected using interviews with limited employees specially specialists who have frequent involvement on major breakdowns. Qualitative data are helpful for further investigation of facts and unintended outcomes of a study. Moreover, the results of the qualitative data analysis cannot be generalized to respondents outside of the study and are only indicative of the group under investigation. *Qualitative data collection methods play an important role in impact evaluation by providing information useful to understand the processes behind observed results and assess changes in people's perceptions of their well-being* (Kadir S., 2016). A semi structured format has been used during the interview to adjust the formally structured question based on the respondent's response and narrate the sense of the question to the required direction and get better clarification based on the respondent's experience.

The quantitative data has been collected via secondary data and questionnaires. The questionnaire has been developed in five-point Likert scale for most of the questions and a multiple-choice question where the nature the question was not going to be replied to the five point Likert scale developed. An open-ended question has also been asked at the end of the questionnaire.

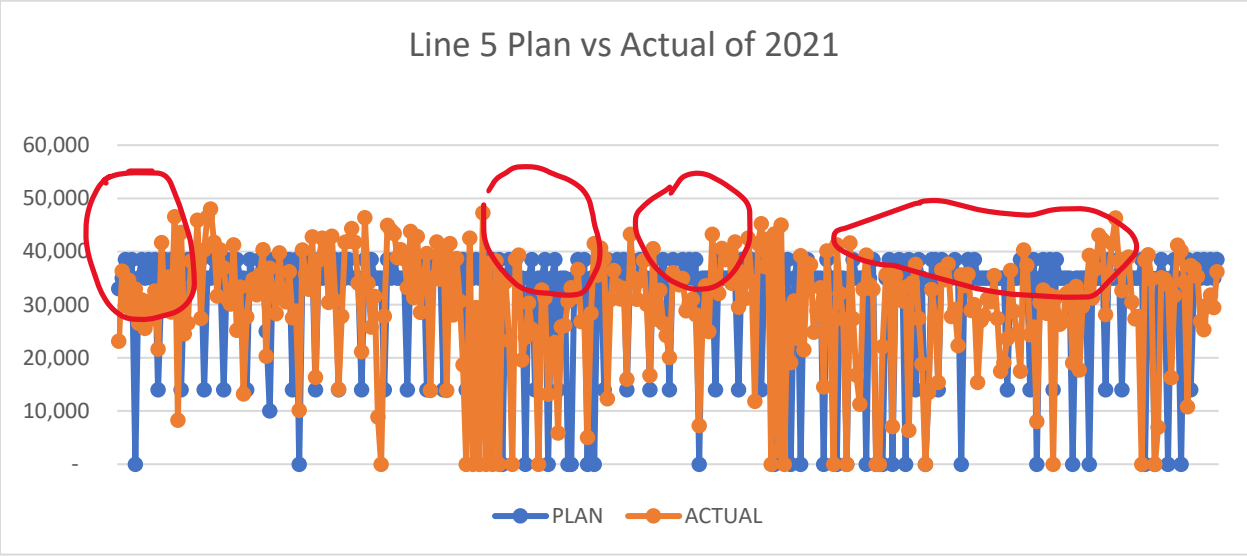
The objective of data collection is to acquire quality and reliable evidence which then can be changed to rich data analysis and helps to achieve credible and trusted answer to the research question stated on the research problem (Kabir S., 2016).

CHAPTER FOUR

4.0 Result and Discussion

The data analysis section contains the quantitative data analysis which has been gained both from primary and secondary sources. While the qualitative data analysis has been done by analyzing the interview conducted with specialist maintenance teams of the plant. To give a vivid picture for readers, the 2021 production plan vs actual performance has been displayed below.

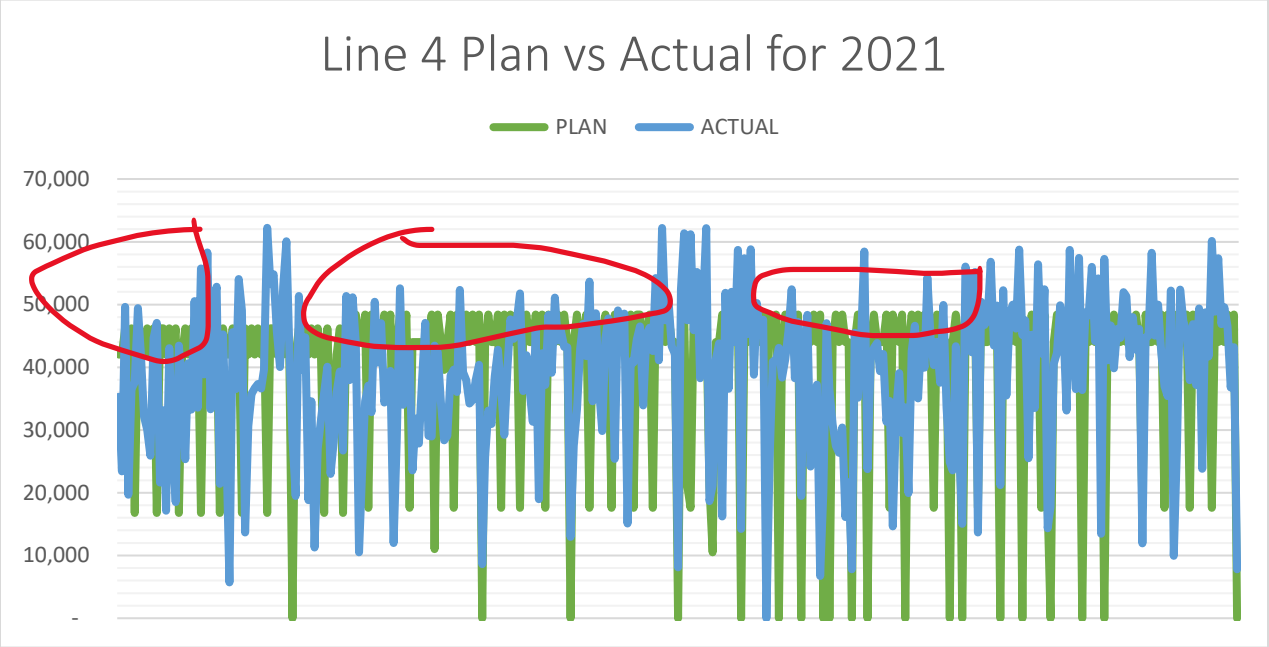
Figure 4.1: Production plan Vs Actual performance graph of production line 5 of year 2021



As can be seen from the graph, the areas highlited show great variation between the production plan and actual performance in 2021 business year. In most day of the year, the line has produced below plan and one of the contributors of below plan performance is due to equipment breakdown and other issues.

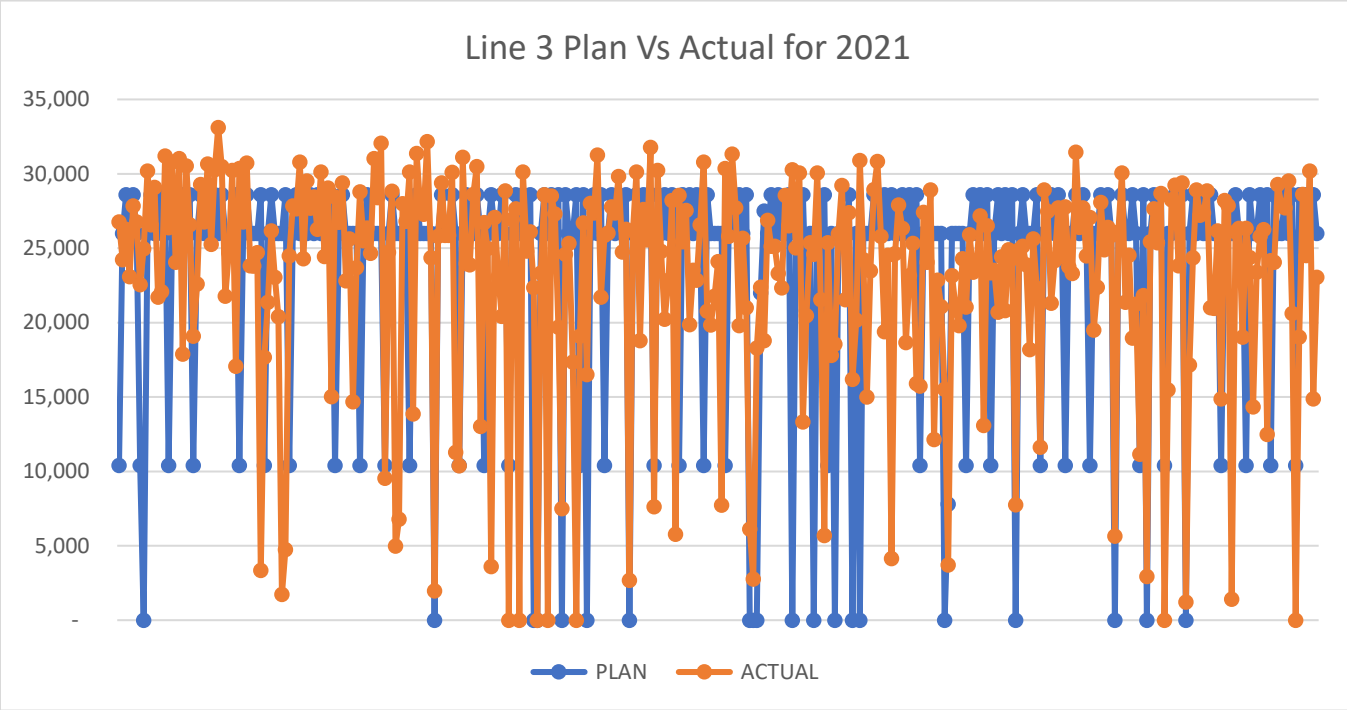
The list of major equipment breakdowns for production line 5 has been shown below and has been analysed later in this paper. Greater flactuation or variance has been seen which need more infasis to identify the problems and work for smooth and sustainable performance on this line.

Figure 4.2: Production plan Vs Actual performance graph of production line 4 of year 2021



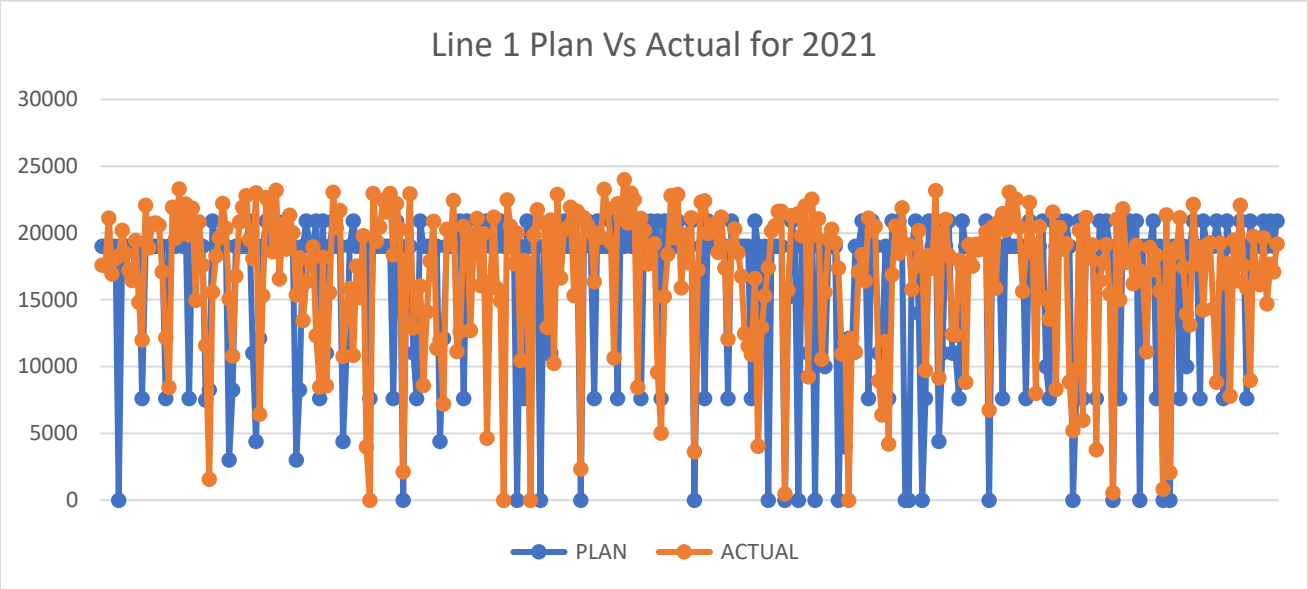
In this graph we can see that there is under performanc for longer times which requires deeper investigation and with action plans generated needs the intervention of top management to bring the production line to better performance. The breakdown chart clearly shows the challenges on the line that there is a problem of sustainable availability.

Figure 4.3: Production plan Vs Actual performance graph of production line 3 of year 2021



Here we can see a better performance where even in quite several days the actual performance is greater than the plan production volume. The breakdown chart can also show the improvement interms of availity of the production line. And there was improvement window to do make the line utilize the potential and maximaze the productivity.

Figure 4.4: Production plan Vs Actual performance graph of production line 1 of year 2021



In this production line it can easily be observed that there was a best performance when compared to other lines. And in most of the cases, the line has performed greater than the plan. But still there are improvement area to unleash the potential adds up to the company's growth. Moreover, the breakdown chart showed a better performance being under the standard breakdown set point and showing a better availability state.

Figure 4.5: Breakdown percentage of production lines in Addis Ababa plant on monthly basis for Year 2021

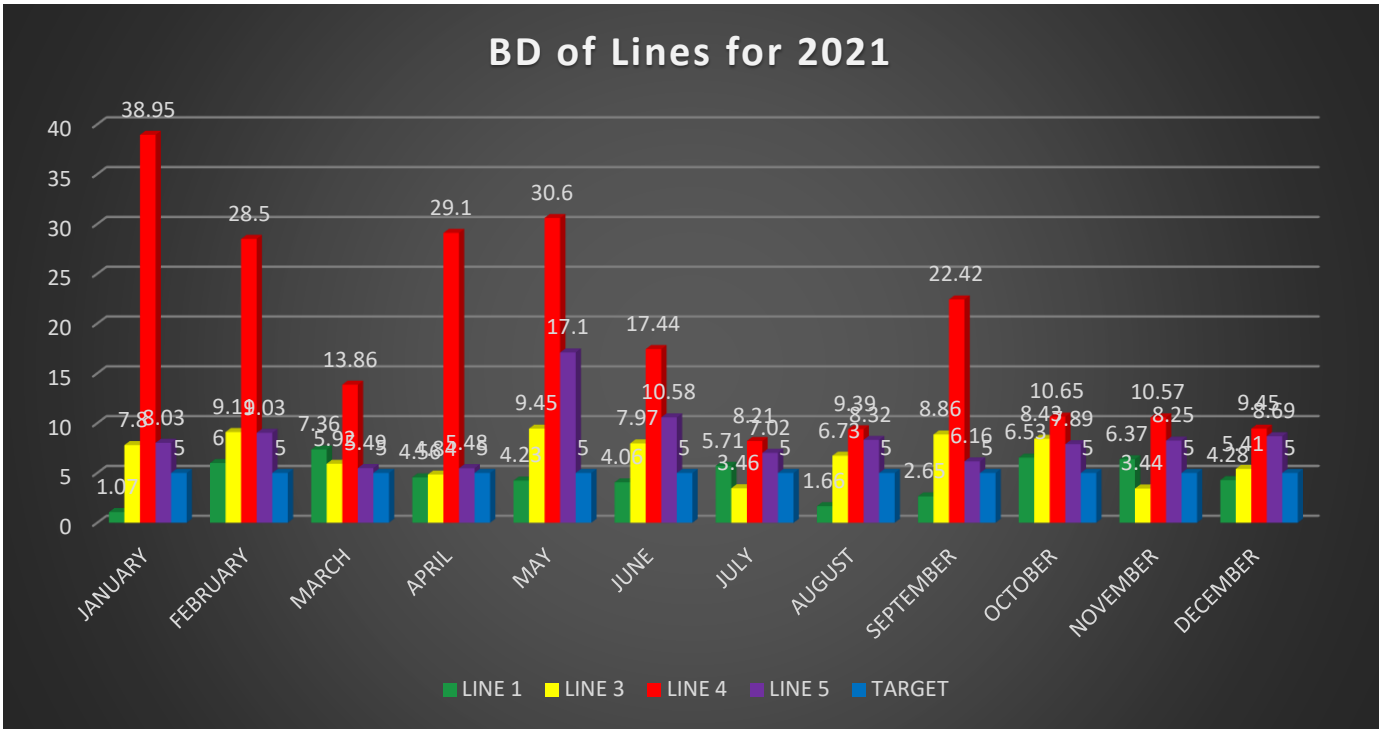


Table 4.1: Product lost due to equipment breakdown per equipment of year 2021 for production lines 1,3 and 5

	Line 1	**Line 3**	**Line 5**
Equipment /Machinery	Case lost	Case lost	Case lost
Empty Crate conveyor	8,297	14,630	14,027
Case unpacker	0	66,633	68,724
Empty Bottle Conveyor	32,989	64,871	59,282
Filler	62,458	57,363	284,509
Bottle washer	12,298	51,113	51,733
EBI	10,195	21,759	7,440
Blender	10,738	2,896	35,333
Capper	40,733	69,350	126,107

	Line 1	Line 3	Line 5
Equipment /Machinery	Case lost	Case lost	Case lost
Packer	-	83,450	36,267
Full Crate Conveyor	12,494	3,975	11,733
Total case lost 2021	**212,404**	**495,990**	**789,555**
Total Plan of 2021	**5,734,350**	**8,026,300**	**10,298,500**
BD PERCENTAGE of Lines	**3.7**	**6.2**	**7.7**

Table 4.2: Most frequent breakdown by type and production lost as a result of it for line 1 in 2021.

Production Line	Major Production lost machine	Cause of Breakdown	Frequency	Volume of Production lost
Line 1	Filler	Filler Discharge bottle falling	18	2,806
		Star wheel timing problem	32	1,090
		Filler infeed timing	8	2,431
		Filler timing missing	11	5,321
	Date Coder	Date coder malfunctioning	62	22,202

Table 4.3: Most frequent breakdown by type and production lost as a result of it for line 3 in 2021.

Production Line	Major Production lost machine	Cause of Breakdown	Frequency	Volume of Production lost
Line 3	Capper	Crowner crimping	18	20,225
		Crowner guide	14	8,225
	Case Unpacker	Gripper adjustment	129	25,745
	Date Coder	Date Coder Malfunction	57	42,750

Table 4.4: Most frequent breakdown by type and production lost because of it for line 5 in 2021.

Production Line	Major Production lost machine	Cause of Breakdown	Frequency	Volume of Production lost
Line 5	Filler	Filler discharge bottle falling	37	49,098
		Filler infeed timing missed	6	7,546
		Filling correction	49	57,683
	Date Coder	Date Coder poor printing	29	23,413

Qualitative Analysis

Group of specialists both electrical and mechanical specialists have been interviewed on the practice of breakdown maintenance and its overall effect on productivity and way forward to improve the impact. The electrical specialist group has stated their view as the major contributor of breakdown is spare part availability. According to them, there is lack of proper spare part availability in the plant which leaded to a secondary damage to the machinery when left unreplaced a failed component of a machine. One of the reasons for spare part supply was due to lack of foreign currency in the country.

The other aspect stated was issues related with the behavior of people within the maintenance team to learn new things willingly with a passion. As there are several people working with different background, it's a kind of challenging to make everyone behave similarly. As a result, the team unable to advance to reducing the breakdown percentage even though we encounter sort of similar breakdowns. In addition, as the plant is working in 24/7, when experts come to our plant not all teams get the training or experience sharing opportunity from the expert.

The other specialist interviewed were the mechanical specialists. Their view regarding the reoccurrence and challenge of breakdown being out of standard were stated as the nature of mechanical breakdown most of the time require the support of other person to fix the breakdown on time as a technician is assigned per shift. So for example, if a bearing of a gearbox failed the

single technician would be challenged to dismantle the component and replace by his/her own in a short period of time. So if the breakdown happened on the time we are in the plant, we support each other and fix it as fast as possible. The problem of taking longer time for breakdowns related with mechanical parts would be when the specialist is outside the plant and driving to the plant and work on the breakdown adds to be longer cumulatively.

The other challenge for longer breakdown times was due to lack of spares and the option could be to replace the failed component with a modified part made at workshop. So making the part will take its own time and mount it and test it works or not has been a challenge. Finally, according to the mechanical specialists not getting proper information while we are far from plant would force us to come to plant driving and the unclearness of the problem will not allow us to support online despite minor problem on the ground.

Table 4.6: Demography of respondents

Gender		
	Female	Male
Frequency	8	23
Marital Status		
	Married	Single
Frequency	15	16

Table 4.7: Educational background of respondents

Educational Background				
	High school graduate	Technical & Vocational school	BSC/BA	Masters
Frequency	1	9	13	8

Table 4.8: Current position of respondents

Current Position						
	Line Technician	Line Electrician	Mechanical Specialist	Electrical Specialist	Maintenance Controller	Maintenance Planner
Frequency	11	11	2	2	2	3

Table 4.9: Work experience of respondents in years

Work Experience				
	0 - 2 years	2 - 5 years	5 -10 years	> 10 years
Frequency	1	8	13	9

From the above tables it can be summarized that employees who has worked longer five years are 21 and the most experienced once who have worked in the company more than ten years are 9 suggesting the technical skill those employees have accumulated in their employment period with the company gives the opportunity to reduce the challenges related to breakdown on the machineries if properly managed and organized.

Moreover, more than two thirds of the maintenance team have acquired a bachelor's degree and above educational achievement revealing a team which understands technical details easily or can learn faster.

4.1 Result interpretation of the Likert Scale

The researcher used below interpretations while analyzing the outputs from the survey undergone. The questionnaires have been prepared with the consideration of the respondents.

Table 4.10: Likert Scale interpretation

Liker Scale	Interpretations
Strongly Agree	High level of confidence with the idea
Agree	Mostly taken the idea but there is small disagreement with the case
Neutral	Neither agreeing nor disagreeing with the case lying in the middle
Disagree	Mostly disagree but there is small fact to agree
Strongly Disagree	Complete disagreement with case in discussion

With the above interpretation, the researcher added the ‘strongly agree’ and ‘agree’ respondents and ‘strongly disagree’ and ‘disagree’ together to make a judgement for the analysis.

Survey done on inputs and facilities for Productivity improvement.

Inputs like tools, support from immediate supervisor and skill enhancing trainings and facilities like working environment, equipment layout within the production line and machine component lay out related questions have been asked and the respondents feedback showed that there is positive response given by most of them. Which shows a closer result with the performance of the lines as displayed in data analysis section of this report that all glass line equipment breakdown were below 10% despite the challenges stated. Also signaling areas of improvement to improve the productivity of the production lines further. Lack of proper tools has been a challenge and contributed to bigger breakdown times. And opportunities like CIP (cleaning In Place internal parts) are used to work on preventive maintenance until the equipment is ready for production which is additional time to the planned maintenance of the equipment. A stronger response mechanism on breakdown has been witnessed from the respondents that most of them replied that they get ‘fast’ and ‘too fast’ support on cases beyond their capability.

Table 4.11: Respondents outcome on Effect of Breakdown on production lines productivity

Effect of BD on productivity of lines	SA + A	SD + D	Neutral
Tools challenge during BD	13 + 15	0 + 2	1
Training given based on skill gap of the team	11 +16	1 +0	3
Working environment convenience	7 + 21	0 + 2	1
Equipment lay out in the line convenience for maintenance	7 + 15	1 + 2	6
Equipment component layout convenience for BD maintenance	12 + 14	1 + 1	3
Proper support from immediate supervisor	10 + 15	0 + 2	4

Survey on Effect of Communication and Information on Breakdown maintenance

The general picture of the respondents' view indicated that, there seem to be variation of working structure. Employees who believe that and who disagree on the breakdowns that has happened in the previous with respect to their shift were 5 in number and implies that there could be no clear direction in information sharing within the different shifts of the same production line. Moreover, there were 6 respondents who responded neutral on their knowledge about the shift who worked prior to their shift indicating is no continuous flow of information about breakdown. On the other hand, respondents who replied with agreement on information provision by previous shift 13 of them said they get the information from their counter colleague and 10 from breakdown logbook. From my observation, as the plant is working 24/7, when the incoming shift and the outgoing team immediately leaves the plant and there was not enough time to discuss the whole breakdown history and sometimes there are times due to lack of transportation teams do not come on time.

On question asked 'if respondents know most of the breakdowns that did happened on their lines?', 16 respondents replied in agreement or know the breakdown that has happened on their lines and 8 of them replied with 'neutral' or they know some and did not know others. And also 6 said they disagree and did not know the breakdowns previously. These feedbacks show us that there is lack of information sharing within the team to exchange their experience hence could solve problems with faster time when it happens again and again. The success of each production lines within the plant is the result of team work with all hard work and capital investment that it become a reality.

In that regard, the maintenance team can do better to realize the success of the plant and the company in general.

Breakdown maintenance creates an opportunity to learn new things and give the courage to see from different corners and decide to work out on the problem at hand. However, breakdown affects the morale of employees and management gets disappointed with maintenance team because of breakdown and decrease in productivity of production lines from the thought that preventive maintenance has not been done and lead to breakdown. On the same way 25 of the respondents replied as not enjoying working on breakdown maintenance and wanted to work in a planned schedule for any maintenance for every equipment.

Survey on Effect of Breakdown Maintenance on Cost of Operation

One of the drawbacks of equipment breakdown is the activity incurs cost whether in terms of the spare part used, the manpower utilized or the raw material loss due to operation interruption is cost for a firm. In addition, the most important resource time is also lost until the equipment resumes operation. Therefore, it requires quick and immediate solution be given to the breakdown and resume production to optimize the lost time and cost implication it has on the overall performance. From the survey collected asking if the respondents know the cost of maintenance at the end of their maintenance activity, 14 replied with agreement and 11 replied with 'neutral' and 6 of them said they disagree. The implication of this response is that most of the maintenance team at Addis Ababa plant were not aware of the cost implication at least related with the maintenance activity, which could create a gap in the understanding of how much cost has been incurred on a particular breakdown maintenance and the awareness of to be cost sensitive on breakdown maintenance.

To solve breakdown maintenance on minimal period, the inputs like spare parts, skilled manpower for support and information like history of the nature of breakdown on the machine need to be available and accessed easily. In this regard, the access of inputs being available easily were responded by respondents as 18 said 'agree', 11 replied 'neutral' and 2 said 'disagree'. From the response we can understand that there is window of opportunity to improve the accessibility of inputs for breakdown maintenance and reduce the time to fix the problem so that productivity maximized, and profitability improved as a result morale of employee kept at higher level.

Breakdown calculation awareness has been surveyed and the outcome revealed that there is a small gap of awareness on 7 of the respondents that replied they do not how to calculate or not sure of

the means. It would be better if all maintenance team were having the knowledge of breakdown calculation to know the implication breakdown has on productivity and gives area of improvement for the future.

Survey on Effect of Breakdown Maintenance on Quality of Product being produced.

As a beverage industry, quality is the non-negotiable aspect of the company in principle. In this regard the understanding of quality as the major priority has been confirmed by the maintenance team response 11 ‘strongly agree’ and 19 responded with ‘agree’. However, on the question of the conformation being made by quality controller seemed to be a room of improvement. In that 10 replied ‘neutral’ and 4 with ‘disagree’. The input and assurance that the maintenance being done has no quality risk by the quality controllers is important.

Quality controller involvement avoids the risk of damping non-conforming products after maintenance. The cost implication of losing non-conforming product due to lack of follow up and control could easily be avoided with the involvement of the management team. Minimizing loose due to quality non-conformance maximize productivity of the line and the plant as a whole. On the other hand, quality product consistency in the market creates customer loyalty and trust in effect increasing market share then leading to sustainable profitability and growth as a company.

CHAPTER FIVE

Conclusion and Recommendation

5.1 Summary of the findings

The finding of the study can be summarized as below.

- The Addis Ababa plant alone has lost 150,000 cases of product due to equipment breakdown in 2021 business year, which is close to 450million birr in revenue. This loss does not include the production loss due to raw material shortage, electric and utility related downtimes and other external factors which made the production line unable to produce.
- Breakdown maintenance project handling was not seen to be uniform across all maintenance working in different shifts of the production lines.
- The level of breakdown percentage across all production lines have been found to be varying from time to time and the production plan of the production lines seen to be varying which need top management intervention to have smoother and predictable production plan.
- There has been a lack of smooth information and communication flow about the different breakdown solving tactics shared among the teams for future learning and improvement.
- Several breakdown types happen to be happening frequently with different amount of time of fixing it.
- Quality awareness between maintenance team seem to be stronger but supervisory level from quality controller side reflected to be weak.

5.2 Conclusion

Breakdown of an equipment is inevitable and to maximize the utilization of the equipment, proper preventive maintenance needs to be executed. Even doing preventive maintenance, breakdown of an equipment could happen and need to be monitored being within a certain limit not to affect the productivity and profitability of a company.

In this paper the effect of breakdown maintenance on productivity of production lines, the effect of communication and information regarding the different breakdowns of equipment amongst maintenance team to reduce the time it takes to fix, effect of breakdown maintenance on cost

operation and effect of breakdown maintenance on quality of product after maintenance has been studied. The plant has lost 1.5 million cases of glass product due to breakdown of machinery in the year 2021. Moreover, the breakdown of equipment in the production lines has no regular trained, which need proper assessment and taking action to improve the line availability.

According to the survey conducted, the Addis Ababa plant of East Africa Bottling has lack of proper tool which takes longer time to solve the breakdowns, a lack of training based on knowledge and skill gap were observed. The information and communication of breakdowns with the team has an effect to reduce the amount of time to solve it when it happens for the second time. In this regard, the plant has a gap of utilizing the human capital in sharing the learnings between different shifts of the same production line and within a plant as well. Also, information related to maintenance cost has not been fully accessed by some of the team which have an impact of less cost sensitivity of maintenance works which then have effect on profitability maximization of the company.

The focus of the paper was on breakdown of equipment and the intention of the researcher was to investigate the how breakdown of equipment would be improved by working on the human capital and the support of the management related with spare part issues. Even though, machine downtime could be created by several reasons and avoiding equipment breakdown is impossible, working on the repeatable breakdowns causes and improving the time it takes to solve those would lead to improve the productivity of the lines by increasing its availability. Hence, from the 1.5 million cases lost in 2021, if the company worked and saved the one third of the loss it can save 150 million birr assuming the cost of one case is 300 birr in 2021. As it can be seen on table showing the frequency of breakdowns on different machines, working to eliminate those problems or using best practices of solving those problems can lead to saving the lost production volume to salable product. And the nature of the business across the country are similar hence the findings can be used to improve the productivity of other plants within the country or elsewhere in the world.

5.3 Recommendations

As any corporate organization works for profit maximization, and the business strategy of the company is to produce standard product, working on productivity through increasing production line availability would help improve its productivity. Working on productivity would help the company to reach its breakeven point with lesser time. In that sense, the researcher has made bellow recommendations which could help improve the productivity of the plant as a whole

Working on bellow listed findings would improve the productivity of the production lines by working on

1. Providing necessary tools for the maintenance team
2. Facilitating trainings based on the gap of the maintenance who need additional training,
3. Facilitating information and communication flow within the maintenance team to use the learning for improvement of breakdown fixing and maximize the productivity of the production lines,
4. Improving quality controller supervision would maximize the loss of product due to quality non-conformance after breakdown maintenance which would improve productivity and profitability the plant.
5. It would be better to prepare standard operating procedures for those which have high frequency breakdown occurrence and create a standard specific problem-solving mechanism so that there will not be a variation in breakdown time by similar breakdowns.

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Appendices

1. Questionnaires

Dear Respondents,

I am working my research on "**Effect of Breakdown Maintenance project on productivity of production lines: the case of East Africa Bottling Addis Ababa Plant**; as a partial fulfillment of Master of Art Degree in Project Management in Saint Mary's University. The main aim of this questionnaire is only for educational research purpose. So, I kindly need your support by responding to the below survey with your honest and sincere feedback.

Thanks in advance for your kind support!
Melesse Abate

PART I, Personal Details:

1. What is your current position in the company?

   …….

   A. Line technician B. Line electrician C. Mechanical specialist D. Electrical specialist E. Line process Engineer F. Production Team leader G. Maintenance Controller H. Maintenance Planner

2. Gender: Female ☐ male ☐
3. Work experience in the company in your current position: 0 – 2years ☐ 2 – 5 years ☐ 5 – 10 years ☐ above 10 years ☐
4. Marital status: Married ☐ single ☐
5. Level of education: High school graduate ☐ technical & vocational school ☐ Bachelor of Science/Bachelor of Art ☐ Master of Science/Master of Art ☐

Part II: Effect of Breakdown maintenance on productivity production lines.

6. Proper tool is a challenge during breakdown maintenance causing longer time to fix.

   1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

7. The working environment is convenient for my work.

   1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

8. Training is provided based on my skill and knowledge gap.

   1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

9. The production line lay out is convenient for all kinds of maintenance work.

   1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

10. Machinery lay out like valve arrangement is convenient to work easily on breakdown maintenance.

    1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

11. I use every opportunity like CIP time to do on preventive maintenance.

    1, Never 2, often 3, Neutral 4, most of the time 5, Always

12. I get the necessary support from my immediate manager.

    1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

13. How quick is the support you get during breakdown maintenance when the case is beyond your capability.

    ☐ too slow ☐ slow ☐ fair ☐ fast ☐ too fast

Part III: Effect of Breakdown Maintenance on Cost of Operation

14. I know how the breakdown percentage of our production line is calculated.

    1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

15. I know the breakdown standards of our production line.

    1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

16. If agree, what is the standard.

    ☐ 0% ☐ 0 – 2% ☐ 5% ☐ 6 – 10% ☐ 10 – 20%

17. I know the cost of breakdown maintenance I did at the end of the maintenance work.

    1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

18. I approach breakdown maintenance in quick and creative way.

    1, Never 2, Sometimes 3, Neutral 4, Most of the time 5, Always

19. I get necessary inputs like information, spare part, skilled manpower in a short period of time to give proper solution to the breakdown.

    Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

Part IV: Effect of communication and information on breakdown maintenance time

20. I can get all the breakdowns that has happened in the previous shift.

    1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

21. If yes, how do you get the breakdown information about the previous shift.

⬚ from respective team leader

⬚ from my counter colleague

⬚ from logbook of breakdowns

⬚ from SAP

⬚ by making a phone call to all operators of that shift

22. I know the solutions given to the breakdowns by the previous shift.

1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

23. If agree, how do you get the kind of actions taken by the previous shift.

⬚ get explanation from my counter colleague in that shift

⬚ briefed by the previous shift team leader

⬚ from the RCA done

⬚ from the breakdown logbook of the line

⬚ from a video recorded about the breakdown fixing process

24. Do you share the challenges you face and how you overcome it during breakdown to next shift?

1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

25. I have faced most of the breakdown before and are not new for me

1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

26. I have been given the necessary training on how to do RCA.

1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

27. The checklist covers most of the equipment to address preventive maintenance and helped in reducing breakdown on each equipment.

1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

28. The checklist is clear and understandable to execute.

1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

29. Major breakdowns are reviewed every.

⬚ a week ⬚ 2 weeks ⬚ month ⬚ quarter ⬚ 6 month ⬚ year

30. I enjoy working on breakdown maintenance.

1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

Part V: Effect of Breakdown maintenance on product quality

31. Quality controller confirms that whether or not the breakdown work has no risk of product quality.

    1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

32. Production equipment is CIPed after breakdown maintenance to avoid product contamination.

    1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

33. I give bigger priority and care for the effect of product quality during breakdown maintenance.

    1, Strongly disagree 2, Disagree 3, Neutral 4, Agree 5, Strongly agree

34. Please comment your recommendation to consistently meet breakdown standards and increase productivity of your line: ……
    ……
    ……

2. Interview Questions: Below questions have been asked electrical and mechanical specialists of Addis Ababa plant maintenance team

   A. Why do you think is the breakdown maintenance percentage of the plant above the standard and unable to meet the target?
   B. What were the challenges in sharing breakdown tactics within different shifts of same production lines?
   C. What are the main challenges in meeting the production volume as per the plan and avoid redundant breakdowns?
   D. What do you suggest has to be done in the future to have achieved the set standards of breakdown percentage need to be done?
   E. If you have a general comment on how the maintenance practice can be improved better.

   I thank you so much for your time!