ST.MARY'S UNIVERSITY

SCHOOL OF GRADUATE STUDIES

THE EFFECT OF EFFECTIVE MAINTENANCE ON PRODUCTIVITY THE CASE OF EAST AFRICA BOTTLING SHARE COMPANY ADDIS ABABA PLANT

THIS THESIS SUMMITED TO ST. MAY'S UNIVERSITY SCHOOL OF GRADUATE STUDY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTERS OF BUSINESS ADMINISTRATION.

BY: MOHAMMED JEMAL

(ID NO SGS/0482/2013A)

Advisor: Dereje Teklemariam (Associate Professor)

Jan 2023

ADDIS ABABA, ETHIOPIA

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APPROVED BY BOARD OF EXAMINERS

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External examiner	signature
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Internal examiner	signature

DECLARATION

I, undersigned declared that this study report or thesis is my original work prepared under the St .Mary's university guide line of thesis preparation and evaluation. All source of material used for this thesis have been fully acknowledged. I further confirm that the thesis has not been summited either in part or in full to any other higher learning institution for the purpose of learning any degree.

Mohammed Jemal ----------

St. Mary's university Addis Ababa Jan, 2023

ENDORSEMENT

This thesis has been submitted to St. Mary's university school of graduate studies for examination with my approval as university advisor.

Dereje Teklemariam (Dr.) ----------

Advisor signature

St. Mary's University Addis Ababa Jan, 2023

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ACKNOWLEDGEMENT

Frist and for most I would like to praise almighty god for all its uncountable gifts through my life

My next gratitude goes to my advisor Dr.Dereje Teklemariam for all his constructive comments in this study.

I am also very grateful for my family and friends who were beside me throughout my endeavor in their moral and other supports.

My gratitude also goes to East Africa bottling share company management teams and employees for giving me support during conducting this study and allow me to collect the data.

Finally I would like to forward my deep gratitude to all individuals who contribute their knowledge, time, resource and energy for the successful completion of this study.

LISTS OF ABBREVIATIONS

AM	Autonomous maintenance
BPM	Bottle per minute
DMAIC	Define, measure, analyze, improve, control
EABSC	East Africa Bottling Share Company
FBI	Full Bottle Inspector
FGD	Focus Group Discussion
HFI	Hold For Inspection
KPI	Key Performance Indicator
MTTF	Mean time to failure
OEE	Overall equipment effectiveness
PM	Preventive maintenance
5S	sort, set in order, shine, standardize and sustain
TPM	Total Preventive maintenance

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ABSTRACT

The aim this thesis is to investigate the current state of the maintenance in the coca cola company Addis Ababa plant line three and to identify process bottlenecks. After recognizing the process bottleneck equipment, situation is analyzed thoroughly by using root cause analysis. Based on the root cause analysis, improvement activities was performed and measured. Current state analysis was conducted from production downtime and spoilage data available. Final implications was measured by using overall equipment effectiveness as indicator. Therefore, theoretical section was focusing on maintenance in manufacturing environment and connected to company's business. Moreover, background theory discussed the total productive maintenance and process improvement. The empirical section was qualitative and quantitative research based on implementation of chosen method. The current case company maintenance state was measured before the implementation, the measured data indicate that OEE is slightly low below target, and defect product which hold for inspection is high above target average by 7% .similarly maintenance situation was measured two months after the new method or tag system implemented.so the measured data indicate that OEE increased above target by 2.16% which directly increase machine availability, increase production time and reduce defect product. The results of the study was visualizing the implications after the maintenance method improvement. As a result of the tagging system implementation, overall equipment effectiveness (OEE) improved significantly during the two month evaluation period. Therefore, it could be summarized that when improving company's maintenance method, it was actualize as better production figures and business result. In addition, challenges related to the maintenance in the company were also identified in communication between personnel. Implementation of the tagging system increased the amount of communication related to maintenance activities. Tag review meeting practice was established and held on regular basis which involves whole manufacturing competency as shared tags between departments.

Key words: Improvement, bottleneck, root Couse analysis, total preventive maintenance, tag system, autonomous maintenance

CHAPTER ONE

1. 1 BACKGROUND OF STUDY

Nowadays manufacturing companies are competing globally and gaining the competitive edge to rivals has become essential for the business. Strategy means making things better by performing unique and well-chosen activities remarkably different than competitors. This is still valid statement from Porter (1996), how he defines the profitability for a company after two decades. By doing activities better with added value to the customer, company is able to get higher price from the product. It is not easy task to perform in some industries. For example, when trying to achieve this differentiating step in manufacturing companies where the product is exactly same, also when equipment and processes are fundamentally similar, it can be challenging.

Operational effectiveness happens by improving processes. Therefore achieving better business position. Operational effectiveness will lower the costs used in making the product. According Porter (1996), Global competition has forced companies to renew their processes. Continuous improvement has gained solid foundation as part of company's strategy driving towards the zero defects methodology. Japanese industry has shown it to world how operational excellence could be achieved by different methods, tools and mindsets. Quality-thinking in all areas as error-free is in the attention on manufacturing. All manufacturing companies do base their production in some sort of machinery or automation. This equipment is making the profit to the company when it is running without unplanned stops or breakdowns. When trying to achieve the best return on investment from the manufacturing equipment, it is truly essential to recognize that efficient maintenance is vital role (Hayes, 1981). This vital role of maintenance is also explained through production output as indicator which is strongly influenced by equipment reliability and maintainability. It has been recognized that proper maintenance system will improve equipment availability and reliability (Sharma, 2012).

Total productive maintenance (TPM) is part of Lean methodology and it focuses on getting more production by lower costs by focusing in problems and breakdowns of manufacturing equipment. TPM aims to use all the capabilities available in the company for improving quality, reliability, safety and reducing waste by integrating maintenance and operations. TPM is to find out the most value-adding activity for the workers. It also emphasizes the importance of operators which are proactively taking responsibility of equipment condition. It is rarely realized that maintenance improvement will lead to cost reduction which is often multiplied in profit when comparing similar increase in company's revenue (Levitt, 2011). TPM is the hardest part of Lean tools to implement, but at the same time it is the tool which could make the biggest difference (Rubrich, 2016). This study

analyzes the effects to production equipment utilization when improving maintenance system in a high-volume manufacturing company.

Manufacturing beverage in East Africa bottling Share Company had faced simultaneous problems with manufacturing equipment. Unplanned stops or breakdowns are cause of the problem which is dragging the company behind the budget. Even if a lot of support from internal and external maintenance companies, there are problems which has stayed unsolved and are still causing down time. Here it's not required to mention the new upcoming challenges when machines are starting to age. There has been few major breakdowns which has caused production to stop for days partly because of mistakes made during the installation, but also caused by lack of adequate maintenance. Another measure problem is working in shifts. Due to this, there has been lot of discussion and dissatisfaction about the fact that information does not pass between shifts adequately. In addition to lack of communication between shifts, but also between shop floor and management. As the inspection report of 2021 shows communication was highlighted as one of the issues.

1.2 STATEMENT OF PROBLEM

Starting from industrial age up to recent time maintenance work was equivalent with extinguishing fire. Maintenance of that time aimed to fix equipment as it broke down. So effectiveness of maintenance was measured in time of fixing broken equipment. Now days, it was recognized that maintenance should be performed in a way which aimed to prevent breakdowns. Company's manufacturing process and strategy defines how maintenance strategy is choose (Laine, 2010). Challenges that rises from maintenance are multidimensional in manufacturing environment. East Africa bottling Share Company is one of the beverage manufacturing company, where companies are trying to satisfy their customers increasing demands, at the same time they are forced to pursue for higher quality, faster responses and better performance. As companies are trying to survive in this kind difficult situation, the maintenance quality problem is become one of the bottle neck problem. Due to this the company is losing a lot of production time and exposed to different kind of unplanned expenses. So Companies must rethink their business processes, reorganize their production and focus on predictive rather than reactive maintenance methods. Management concepts should be also reevaluated to be more flexible and integrated. Emerging requirements has led to situation where the need for maximizing equipment availability is ensured, production cost effectiveness and safety has increased. Therefore to ensure the above condition one of the most important factor to be considered is optimization of the maintenance strategy. Developing optimized maintenance strategy and approach is very important to achieve great impacts in overall. It is essential to recognize that effective

maintenance is key factor when improving equipment availability, cost optimization, product quality, environmental issues, and zero waste and energy control (Artiba et al, 2005).

East Africa bottling has a goal to stay as the leading soft drink bottling company in Ethiopia. According to Ethiopian Investment commission (June 2019), East Africa bottling is set to build a 70 milliondollar new factory and invest 300 million dollars in the past five years. In this regard, it's vital step to ascertain its maintenance strategy and approach that support company to meet or keep up and excel with the company goal. So this study was tried to examine to what extent the effect of effective maintenance has impact on the productivity on East Africa bottling Share Company, Addis Ababa plant on line three.

1.3 THE RESEARCH QUESTIONS

The study was guided by responded to the following research questions.

- What is current maintenance strategy of the case company?
- What are the case company bottleneck problems concerning with maintenance?
- What are the key area for improvement concerning with maintenance? and
- How maintenance should be improved in the current situation?

1.4 RESEARCH OBJECTIVES

1.4.1 GENERAL OBJECTIVES

The overall aim of the study was to investigate the current state of case company's maintenance process and identify the most significant areas for improvement. Based on analysis of the current state, bottle neck problems were identified, action plans were prepared and improvement project team was established based on the resources available in the case company and perform improvement project on these selected area. After improvement work was done the improvement result was measured.

1.4.2 THE SPECIFIC OBJECTIVE

The followings are the specific objective which the research was try to address.

- To find appropriate maintenance method according to the situation of the company. Then the method was implemented and implications analyzed in quantitative data analysis methods.
- To improve defective product due to quality issues.
- To reduce the spare part cost.
- To improve equipment efficiency and availability.
- To increase productivity by increasing production time

1.5 SIGNIFICANCE OF THE STUDY

Significance of the study is very important part of the study .since it was highlighted or indicated what the researcher want to get as the end result. So the Significance of the study of this study comprises the following.

Generating the knowledge which help the case company to Model the maintenance strategic method and approach could be notable topic for further study was one of the significant of the study. However it's not look in to consideration when conducting this thesis.

The main significant of the study was to answer practical problem of the case company concerned with quality of maintenance by improving the current state of case company's maintenance process and identify the most significant areas for improvement. depending on the analysis of the current state, improvement project team was established ,the action plan was prepared and implemented accordingly.so when improvement was done it improve the maintenance effectiveness which is directly improve the availability of equipment for production. So this was improved productivity of the case company by reducing unplanned machine stoppage or down time, reduce cost of spare parts and decrease defective product or increase the quality of product. In addiction it improve the life standard of the case company's employees because they get yearly salary increment and bonus.

1.6 THE SCOPE OF THE STUDY

The study was conducted as an action research in nature and focus on find method for improving maintenance process only in East Africa Bottling Share Company Addis Ababa plant, line three (3) .This study was performed in two month. This time was only for performing improvement project work and to measure the result.

This study was used longitudinal research design in which data was collected from respondents more than one time. Quantitative primary data like overall equipment effectiveness (OEE) measurement, downtime measurement, and spoilage amount was collected from case company information system. In addition to this, data concerning with existing maintenance practice was collected as qualitative primary data from the concerned employees by interviews.

1.7 LIMITATION OF THE STUDY

The study was limited on the case company maintenance improvement only due to time, resources available for the improvement project. Since the nature of the manufacturing business is equipment oriented, maintenance plays big role in successful business execution of the company.

This study was tried to improve maintenance work or activities through the analysis of the current state company's process by taking one year break down data from the company information system, identify bottleneck problem or improvement area, improvement project was established depending on the resources available in the case company, improvement project work was implemented and improvement was measured quantitatively. The drawback may rise due to the size of data, case company commitment and support for the study and response from target population.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 THEORETICAL FRAME WORK

Maintenance should be element that increases gross productivity. Maintenance is always included as part of continuous improvement strategy and as part of company's manufacturing department's main strategy. Daily maintenance agenda is not enough when goal is to get high machineries utilization rate and productivity figures. Certain elements should be taken into consideration according to TPM to achieve the goals set, these elements are also called as pillars (Laine 2010).

Challenges are multidimensional in manufacturing environment. Where companies are trying to satisfy their customers increasing demands, they are forced to pursue for higher quality, faster responses and better performance. As they trying to survive in this kind of difficult situation, companies must rethink their business processes, reorganize their production and focus on predictive rather than reactive maintenance methods. Management concepts should be also reevaluated to be more flexible and integrated. All these factors had forced manufacturing companies to develop production lines with complex systems where automation, integration and flexibility has been considered thoroughly. Emerging requirements has led to situation where the need for maximizing equipment availability, production cost effectiveness and safety has increased. Therefore, one of the most important challenge to be considered is optimization of the maintenance strategy. Developing optimized maintenance strategy and approach is possible to achieve great impacts in overall company's goal. It is essential to recognize that maintenance is key factor when improving equipment availability, cost optimization, product quality, environmental issues, and zero waste and energy control (Artiba & Riane, 2005).

Maintenance engineers are still focusing on how fast they are fixing equipment when it breaks down as mentioned in the above. The role of maintenance engineers is to prevent all losses caused by equipment, not to fix breakdown as fast as possible. According to Mobley (2002), optimum availability of equipment is the most important task. Equipment should be targeted to be online always and in operating condition. Optimum operating condition should be considered in all areas, whereas smallest problems and stops will form a huge loss when calculated together. Every small stop will effect on plant overall performance. Maximum utilization of maintenance resources is important task to be fulfilled as well, even though maintenance actions are generally minded as minor part of company's total operating budget. It is the maintenance manager's responsibility to control resources effectively, like internal and external maintenance labor, spare parts inventory and repair parts.

One mission is to focus on optimum equipment life which could be achieved through implementation of different maintenance programs. Even the best programs could fail and unexpected breakdown could appear. In that point maintenance organization should be ready to react rapidly. When evaluating different maintenance types there are three main indicators which could give a hint to company.so the followings are the three indicators.

- What is their current situation? If production is interrupted by different maintenance reasons more than 30 percent of total occurrences, we can say that management philosophy is reactive, more or less breakdown oriented. For a comparison, it is evaluated that target for maintenance related stops for competitive manufacturing company is less than 1 percent of overall occurrences.
- Next indicator for inefficient maintenance is overtime amount. If overtime covers over 10 percent of total labor budget it is easy to categorize company to breakdown type. Appropriate target is approximately 1 percent of overtime.
- Last indicator is labor usage. This is part where is recognize place for improvement when reflecting to my own experiences in manufacturing companies. Efficient management style will utilize maintainers to perform preventive maintenance actions for over 90 percent of working time. Actually, worst case is to only monitor what equipment is breaking down next. Reliability of critical plant systems is based on well-managed maintenance organization (Mobley, 2002).

It has been mentioned repeatedly in literature that maintenance does own a very important role in companies' agenda, whereas it is directly related to their competitiveness. Of course, when manufacturing systems are measured in availability and reliability metrics they are corresponding to company's economic situation. Manufacturing equipment is company's most important capital asset and the main concern lies on it is deterioration and failure. At this stage some sort of the preventive maintenance is necessary for restoring and maintaining equipment in operating condition. With no doubt, goal for maintenance budget is to keep the expenses as low as possible. In real life, maintenance managers are forced to answer the question to maintain or not to maintain. Problem lies on the fact that it can't be predicted accurately when machine breaks down. Is equipment performing reliable after maintenance, which will cause certainly downtime for it? Is the costly operation worth it? However, if equipment breaks down and spare parts are not ready and maintenance planned, it will cause more downtime than planned maintenance. This is the situation where maintenance manager should choose his strategic approach or set-up maintenance system according to different Preventive Maintenance methodologies (Artiba & Riane, 2005).

Maintenance work in the Manufacturing plants normally are categorized under two types of maintenance strategies. These are run to failure and preventive maintenance.

Run-to-failure:-Run-to failure approach is simple. When equipment breaks it will be fixed. Money spent on maintenance stays zero until equipment breaks down. Sounds reasonable, but when equipment finally breaks down it will be expensive case. The most significant costs are associated with high spare parts inventory, high overtime labor, high equipment downtime and low production availability. This approach is actually reactive. When failure appears then maintenance team reacts. Actually, quite rarely there is not preventive actions at all, like lubrication, cleaning or machine adjustments. Running business like this is really risky. It has been evaluated that making preventive maintenance actions like planning and scheduling upcoming repairs is three times cheaper than waiting equipment to break down and then fix it (Mobley, 2011).

Preventive maintenance programs are mostly based on elapsed time or hours of operation per equipment. Most commonly, there is evaluated time to failure which is called also mean time to failure (MTTF)
In preventive maintenance, during normal equipment operation time, condition of machinery was monitored whether it should be repaired earlier than planned. Predictive maintenance is to monitor the elements of breaking down. Especially, equipment will be inspected more carefully like vibrations, heat generation, leakages, pressures and other significant symptoms for breaking down earlier than expected (Mobley, 2011).

Preventive maintenance economics: - Like in any other investment, maintenance investment does also follow the characteristic process of financial justification for the project. First, the initial and current expenses are compared with expected benefits. Then benefits are calculated to cost savings and increased profits. If return on investment is calculated positive in reasonable window of time, probably project will be worth investing. It must be noted that calculated costs for the project should imply also installation, recruitment and training costs, not only the price of new equipment. Cost justification for preventive maintenance action is at highest when thinking bottleneck equipment in process. If condition of the machine is not monitored carefully, it will be tremendous cost when breaking down unexpectedly (Mobley, 2002).

Maintenance budget is usually counted as a cost overhead, fixed sum which is reserved for staff wages, spare parts and consumables. Quite common system is also to evaluate the performance of maintenance department compared to budget. If budget surpluses, even when production suffers lack of maintenance, quality or availability, it is evaluated positively. This is wrong mindset, instead we can justify that preventive maintenance is actually investment, not expenditure. Nevertheless, reliable data for justifying the return on investment should be presented before implementation. Usable indicator for improvement could be equipment performance and then translated to financial benefits. The cost of lost production time is indicator which could be translated also to lost units made and then again translated to financial data (Mobley, 2002).

Total productive maintenance (TPM) is holistic view of the impacts of maintenance in production. Total Productive Maintenance (TPM) has been developed in Japan and spread across the world by Japan Institute of Plant Maintenance. TPM, consist eight (8) pillars. These Pillars are focused on Improvement, Autonomous Maintenance, Preventive Maintenance, Education and Training, Early Equipment Management, Quality Maintenance, Office TPM, Safety, Health & Environment (Sharma, 2012).

TPM means that whole organization is making commitment for sustain, develop and maintain manufacturing capacity. One of the leading principles in TPM is that every employee participates. TPM is depending on teamwork and for managers especially coaching these teams to top performance. When creating favorable environment for motivation growth, we can achieve highly motivated employees playing in our team (Laine, 2010). There are several similar development methods and tools with TPM like TQM (Total Quality Management) and JIT (Just-In-Time) which are supporting each other (Tuominen, 2010). TPM was implemented also by Toyota and other Japanese manufacturing companies. TPM relies on five different sections like maintaining quality, productive maintenance, manufacturing technique, cleanliness & order and highly skilled employees. However, Japan Institute of Plant Maintenance defines that TPM should be implemented according to following minimum procedures.

- Set goals which will maximize equipment effectiveness.
- Create sustainable productive maintenance system.
- Engage all departments – planning, production, quality, maintenance.
- Involve whole organization in TPM program.
- Create focus groups to motivate and support maintenance.

TPM is way of thinking that maintenance is everywhere, it is not anymore limited to corrective or preventive maintenance actions. In the definition of maintenance according to the TPM belongs that maintenance is emphasized in relation between company's overall income and cost structure.

Five S (5S) is pre-phase for TPM implementation by preparing optimal circumstances by minimizing the environmental effect to the work flow. 5S forms the foundation for other TPM implementation activities by making positive impact to work force motivation in early stage. Implementation of 5S is vital in terms of working safety, quality, efficiency and downtime. Although, 5S system requires constant observation to be successful. The 5S philosophy is focusing on simplification of the working environment. There are five guidelines in 5S system (Korkut et al, 2009).

- Sort

- Set in order
- Shine
- Standardize
- Sustain Sorting and arranging working environment to be logical is the first rule.

2.2 EMPIRICAL REVIEW

Maintenance is always included as part of continuous improvement strategy and as part of company's manufacturing or maintenance department main strategy. Quality maintenance is maintaining strongly formed by the combination of other pillars like Monitoring and inspecting equipment condition has vital role for manufacturing company. Quality maintenance aims to react before equipment variation or defects take place. So using TPM which are strictly related to ideal maintenance performance and zero loss methodology overall equipment effectiveness (OEE) must be improved. Overall equipment effectiveness (OEE) calculation is way to measure how successfully plant maintenance are controlled. OEE is one of the parameter which is used to measure the quality of maintenance. OEE could be described as the ratio between actual equipment output and the maximum equipment output in optimal manufacturing conditions (Almeanazel, 2010).

In manufacturing industry Overall equipment effectiveness (OEE) is viewed as key performance measure considering all kind of processes and equipment. In the year 1988 Nakajima introduced OEE as TPM performance measurement system which focuses into manufacturing equipment by offering clear overall measurement. In todays' manufacturing world it has become essential tool for productivity measurement. Overall equipment effectiveness (OEE) calculation has evolved by the fact of adequate metrics in some areas like material input, labor and planned downtime. However the accuracy of Overall equipment effectiveness (OEE) is depending on the quality of collected data (Sharma, 2012). Overall equipment effectiveness is simple way to measure current status of production. Higher productivity could be achieved by utilization of man, machines, material and methods. OEE consists three essential parameters. These parameters are Availability, Performance and Quality. So these parameters were described as the following.

Availability is the first Overall equipment effectiveness (OEE) factor having impact on total OEE. Availability is calculated from the ratio of planned production time and actual run time (Vorne Industries Incorporation 2016). Availability = Run Time / Planned Production Time. Planned production time equals to the time that equipment is expected to produce good units. It comes from planned stops like maintenance days or similar schedule losses subtracted from all time available (Vorne Industries Incorporation 2016).

Planned Production time = All Time – Schedule Loss Run time is calculated by subtracting stop time from planned production time. Stop time or downtime is defined as unplanned stops, breakdowns or planned stops like changeovers (Vorne Industries Incorporation 2016).

Run Time = Planned Production Time – Downtime For example, if beverage filler is planned to run 24 hours per day and changeovers and breakdowns take 5 hours from day, availability will be (24-5) / 24 = 0,79 = 79%. In performance rate calculation there is two main factors needed, ideal run rate and total output including defects. Ideal run rate is designed maximum speed for equipment to produce good parts (Almeanazel, 2010).

Performance = (Total Output / Run Time) / Ideal Run Rate .For example if filler running speed is 1500 BPM (bottle per minute) and total output is 1596000 bottle then the calculation is executed as follows.

(1596000 bottle / 1500 bottle per minute) / (19 h * 60 min) = 0. 93 = 93%. Quality is last factor of OEE calculation. Quality rate indicates the effect of rejected parts produced compared to total output. These are products to be scrapped or reworked (Almeanazel 2010).

Quality = (Total Output - Defects) / Total Output .For example if filler produces 188000 bottle which does not meet the quality standards the OEE value will be calculated as (1596000 - 188000) / 1596000 = 0,88 = 88%. Eventually, we can calculate the total OEE value for the filler .example used. OEE = 0,79 * 0,93 * 0,88 = 0,64 = 64% .To gain Japanese World Class PM Excellent Award plant has to achieve total OEE over 85%.

Calculation of OEE should always be modified and concerned according to the process under investigation. In most of cases calculation model is chosen based on available data collection and analysis method. Especially, when there are many different products, batches are short with large amount of changeovers. Naturally, quality of the raw material have an impact on performance. Therefore, there is possibility for greater variation of OEE average. Nevertheless, it is not crucial when OEE calculations from same process are conducted similarly and then could be compared as long-term results between each other (Laine, 2010).

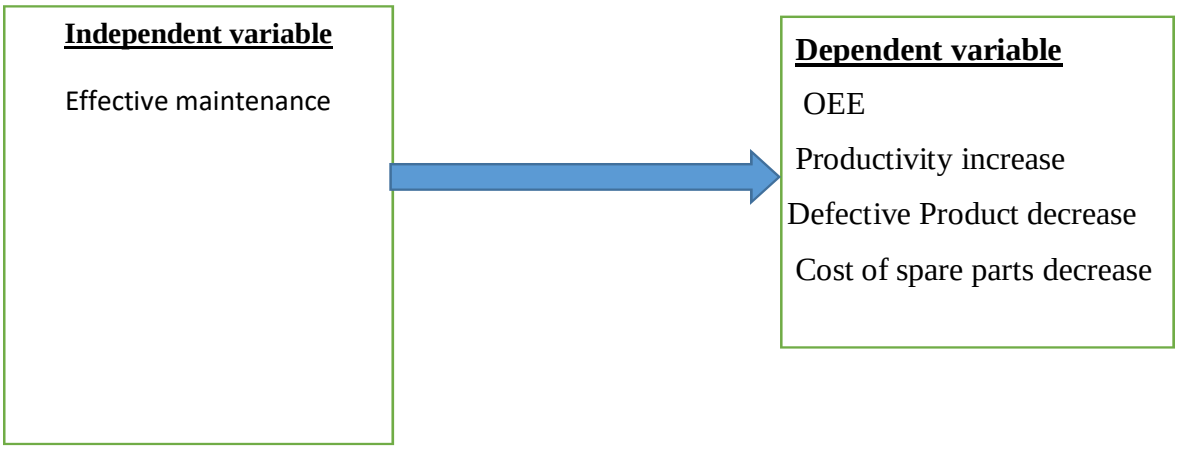
2.3 CONCEPTUAL AND THEORETICAL FRAMEWORK

2.3.1 CONCEPTUAL FRAMEWORK.

As it was described in the theoretical review section the maintenance in the manufacturing company is key factor in improving equipment availability, cost optimization, product quality, environmental issues, and zero waste and energy control (Artiba & Riane 2005).

Six big losses in TPM are strictly related to ideal performance and zero loss methodology and OEE calculation is way to measure how successfully losses are controlled. Overall equipment's effectiveness (OEE) could be described as the ratio between actual equipment output and the maximum equipment output in optimal manufacturing conditions (Almeanazel, 2010).

In manufacturing industry overall equipment's effectiveness (OEE) is viewed as key performance measure considering all kind of processes and equipment. So as the conceptual framework shown below indicates, the independent variables is maintenance quality or effective maintenance and dependent variables are over all equipment effectiveness(OEE), increase productivity, decrease Defective product due to quality issues and decrease cost of spare parts.so this study was tried to examine the effect of effective maintenance which is independent variable on dependent variables like the productivity, OEE, defective product and costs of the spare parts by taking other variable like intermediate variables and other variables as constants.



Conceptual frame work adapted from researchers model of 2015

Effective maintenance is the type of planned maintenance in which artesian replace or maintain machineries in the best way to bring the machineries in the standard conditions. So this type of maintenance aim was to reduce machine break down or unplanned machine stoppage which raised from improper maintenance. Its independent variable as it was described in the above conceptual frame work and it has direct impact or relationship with overall equipment effectiveness (OEE),productivity and product quality while it has inverse relationship with spare part cost.

Over all equipment effectiveness (OEE) was described as the ratio between actual equipment output and the maximum equipment output in optimal manufacturing conditions (Almeanazel, 2010). It is one of the parameter which is used to measure the quality of maintenance in the manufacturing industries.it comprise three essential parameters like availability, performance and quality. It is one of dependent variable in this study as it was described above on conceptual frame work.so it has direct relationship with effective maintenance.

Productivity is the efficiency of the production of goods or services expressed by some measures. measurement of productivity are often expressed as a ratio of an aggregate output to single input or an aggregate in put used in production process.so it's one of dependent variable in this study and it has direct relationship with effective maintenance. That means if quality of maintenance was increased productivity was also increased because of machine availability was increased which increase production time.

Spare part cost is an expenditure or expense for maintenance and repairs that do not materially extend the life of the assets are charged to expense as incurred. It's the cost or expense incurred for spare parts which replaced by worn-out part during maintenance.so it's very critical for any company to be profitable.it one of dependent variable and it has inverse relationship with maintenance quality. That means if maintenance quality is poor or in effective maintenance was done, there is high chance of frequent break down or unplanned machine stoppage which increase the frequency of spare replacement.so if quality of maintenance was increased the spare parts utilization was decreased because of one spare may run the machine for long time.

CHAPTER 3

3. RESEARCH METHODOLOGY

3.1 INTRODUCTION

Research methodology is the process how one researcher perform the research work or activity. Research methodology include research approach (like quantitative approach, qualitative approach or mixed approach.), Research design (like descriptive, explanatory, exploratory, cross sectional and longitudinal),target population, sample and sampling procedure, data source and method of data analysis.so in this study research approach was mixed research approach, research design was longitudinal research design, sampling procedure was non probability sampling procedure, data source was primary and secondary data were used and both qualitative and quantitative data analysis were used as method of data analysis.

3. 2 RESEARCH DESIGN

The research design was longitudinal design in which data was collected from respondents more than one time. This research was conducted as action research. Typical action research is process which aims to change or improve things. Research topic could vary from organization procedures to understanding behind processes and activities. According to Tappura (2009), objective of action research is to change existing activities and to solve problems in organization. Quite often workers were active part of the research and researcher was also taking part to the action behind the research. Action research process includes typically planning, implementation and evaluation phases. In action research, earlier experiences and historical data are analyzed.

3.3 DATA TYPE

Both quantitative and qualitative data type were used. Quantitative primary data was used according to the nature of manufacturing process and improvement. In this case, indicators were over all equipment effectiveness (OEE) measurement, downtime measurement, and spoilage amount are the quantitative data type which was collected from case company information system. Data concerning with existing maintenance practice was collected as qualitative primary data from the concerned employees by interviews.

3.4 DATA SOURCE

Both primary and secondary data were utilized. That means earlier experiences and historical data were collected and analyzed from the case company information system that means SAP system.in addition to earlier experiences and historical data the current maintenance practice of the case Company was collected from the concerned employees by interview.

3.5 TARGET POPULATION AND SAMPLE

3.5.1 TARGET POPULATION

A population is the total collection of elements about which the researcher makes some inferences.The collection of all possible observations of a specified characteristic of interest is called a population while a collection of observations representing only a portion of the population is calledsample. So my target population was yearly operation days (317) of machines which found in line three coca cola Addis Ababa. These machineries were crate conveyor, unpacker, bottle washer, empty bottle inspector filler, empty bottle conveyor, crowner, full bottle inspector, full bottle conveyor and date code or printer. So by using stratified probability sampling technique filler, crowner, empty bottle conveyor and date code were selected for this study. So the break down or unplanned stoppage data concerning with the above machineries were collected from the case company information system. That means earlier experiences and historical data will be collected and analyzed from the case company information system that means SAP system. In addition data concerning with existing maintenance practice and maintenance activity concerned with the above machineries were collected by structural interview from case company's concerned employees or by using census.

3.5.2 SAMPLE SIZE

Basically, accurate information about given population could be obtained only from census study. However, due to time and budget constraint, in many cases, a complete coverage of population is not possible; thus sampling is one of the methods, which allow the researcher to study relatively small number of units representing the whole population. So by using probability sampling stratified sample technique yearly operational days (317) of five machineries were selected and the study was done on them. These machineries are filler, crowner, empty bottle conveyor and date code or printer.

In order to sample the population the researcher was used probability sampling of stratified sampling technique. This study was applied simplified formula provided by Yamane, (1967) to determine the required sample size at 95% confidence level, degree of variability = 0.5.

$$n = \frac{N}{1 + N(e)^2}$$

Where:

n = Desired sample size

N =Total population size

e = Accepted error limit (0.05) on the basis of 95 percent degrees of confidences put into decimal *form*

$$n = \frac{N}{1 + N(e)^2}$$

$$n = \frac{317}{1+317(0.05)(0.05)} = 176.847 =\sim 177$$

3.6 DATA COLLECTION METHODS AND TOOLS

To address the research objectives the main data collection method that was employed in this study are mainly focused collecting on earlier experiences and historical data from case company information system and performing structural interview with concerned case company employees. That means earlier experiences and historical data was collected and analyzed from the case company information system. So earlier experiences and historical data were extracted or collected from the case company information system and information concerning with existing maintenance practice was gathered from concerned employees by structural interview. Frist collecting and analyzing the data and studying the problem from different viewpoints are the main activities that was done. Second, events or meetings where prepared for brainstorming, free thinking and generating ideas was in focused to develop solutions or improvements. Next step was evaluate and select the most potential idea which was lead to most value-adding situation. Final step was to implement this strictly chosen idea on selected machineries during implementation of improvement projects and present the advantages and improvements of it to the case company.

3.7 DATA ANALYSIS AND PRESENTATION

Raw data has no meaning. So to give meanings it needs pass through process of analysis. So both qualitative and qualitative method of data analysis were used for this study. After improvement project was performed again data collection process was performed. The variance was measured with previous data collection and analysis result. Then that data was coded and entered into SPSS. Correctness of data entry was checked accordingly. Through qualitative and quantitative analysis and it was confirmed that conclusions of root cause and Pareto analysis are reasonable. Percentage was used to understand the relationship between the dependent variables like overall equipment effectiveness (OEE), Productivity, product quality and cost of spare and independent variable or (Effective maintenance). The final step was reporting the finding and maintain the achieved improvement. Maintaining, in this case means that new maintenance working standards or procedures was established. Monitoring the results, reviewing the performance of key variables and checking the overall situation periodically was the main activity of the case company if the company has willingness to accept the result of the study.

CHAPTER FOUR

4.1 RESEARCH RESULTS AND DISCUSSION

The main goal of this study was to gain more production time by avoiding unplanned stops or breakdowns and to nourish the communication about the maintenance actions. To meet this goal it was essential to find out bottleneck of the process and analyze the root causes, before taking any actions towards improving maintenance practice. To do this one year break down data or unplanned stoppage and overall effectiveness of equipment (OEE) result were taken from the case company information system (SAP system) and structural interview was done on eight (8) concerned employees which comprise the operators, specialists, electricians, technicians and team leaders about existing maintenance practice, existing maintenance effectiveness and current situation of the case company.

GENERAL INFORMATION OF RESPONDENTS FOR INTERVIEW OR INTERVIEWEES

The demographic description of the interviewees are as the following depending on gender, educational status and work experience.

item	**sex**	**quantity**	**percentage**
gender	male	5	62.5%
	female	3	37.5%

item	**degree**	**Diploma or level 4**	**certificate**
Educational status	6	2	0
percentage	75%	25%	0%

item	Less than five years	Five years	More than five years
Work experience	3	2	3
percent	37.5%	25%	37.5%

The interviewees response's was indicates that, Five (5) participants or70% of participant replied they faced frequent break down after maintenance done, two (2) participants or20% replied shortage of maintenance time and spare parts unavailability and one (1) participant or10% replied that no time for readiness psychologically for planned maintenance task since there was gap on communications. According to interview results we could state that bottleneck was found on the quality of maintenance, shortage of maintenance time, spare part and communication gap respectively.

Based on the collected data from the case company information system (SAP system), about Equipment downtime or unplanned stoppage and products hold for inspection due quality issues or spoilage indicators were also indicated there was huge unplanned stoppage on different machines and a lot of defective product which was hold for inspection in line three. Based on the collected data from SAP system result we could state that there is low machine availability and low machine efficiency and effectiveness.

In addition collected data from SAP system about Overall equipment effectiveness (OEE) results before improvement project indicated that machine availability or planned overall equipment's (OEE) was below target. That means there is low machine availability, low plant performance and high defective product in this line.so when compiled both historical data and interview result together there is an indication that indicate gap on existing maintenance practice which need improvement. That means overall equipment effectiveness need improvement.

Based on the above collected data focus group discussion and root Couse analysis team were established to identify bottleneck problem. Based on focus group discussion and root Couse analysis team bottle neck problems were identified and some machineries were selected for the improvement project by stratified probability sampling techniques. Based on identified bottle neck problem improvement team was established and improvement project was started on the selected machineries like filler, crowner bottle conveyor and date code or printer. Coaching technician and electricians ,Solving the spare parts issues, improving maintainers skill gap, changing their mind set, perform Pre maintenance meeting, perform post maintenance meeting, tagging system method and perform tag review meeting were some of identified action plan by Focus Group Discussion (FGD) and implemented by improvement project team on these machineries. So the identified action plan were implemented by improvement team during improvement project implementation on these selected machineries.

After improvement project implementation was completed data was collected again and compared with data collected before. The result of data comparison was indicated that machine availability or OEE was increased by 2.16%, Communication and co-operation in maintenance were also improved, defective product or HFI spoilage was reduced and productivity was also increased due to increased production time or due to reduced break down, reduced unplanned stoppage time and reduced rework work on quality issues. Maintenance activity data was measured in bottleneck area by comparing situation before and after improvement project was implemented. Maintenance tasks generated was increased and it was indicated that number of maintenance task generated was increased due to implementation of tagging system during improvement project.so in the following sub titles results was analyzed and discussed thoroughly. More profound analysis and conclusions will be discussed in the next chapter or chapter five.

4.1.1 DISCUSSION

4.2 BOTTLENECK AND ROOT CAUSE ANALYSIS.

Bottle necks are the major problems that Couse major break down or unplanned stoppage on these selected machineries. Root Couse analysis is the method of finding root Couse for the happened problem or for the bottle neck problem. So the bottleneck was identified simply by root Couse analysis using Pareto diagram to identify from chosen possible causes which are the most major causes for production losses. Data was exported and analyzed from information systems (SAP system) that monitoring production and quality figures such as product hold for inspection (HFI) and production downtime. Downtime is essential factor to be analyzed, because it does have direct influence on plant performance. Defective product hold for inspection (HFI) spoilage is indirect factor, which is causing rework activities like sorting, scrapping and warehouse reservations. As combining these two, it was form a comprehensive review of current situation of case company's bottleneck problems before improvement project. The following table was tried to show yearly Machine's break down time elapsed in hour and production losses in case company from 1/1/21-30/12/21 GC in line three.

Table 4.1 Downtime Pareto Line 3

s/no	machines	Production loss(case)	Yearly stoppage(hr.)
1	Crate conveyor	12941.514	1070
2	unpacker	3979.839	329
3	Bottle washer	12297.959	1017
4	Empty bottle inspector	10195.214	843
5	mixer	10738.339	888

6	filler	62457.877	5165
7	crowner	42680.013	3531
8	Date code	22346.803	1848
9	Full bottle inspector	1269.734	105
10	Bottle conveyor	29384.189	2409

When down time was analyzed unplanned stoppage data from the last year (1/1/21-30/12/21) to identify bottleneck and major downtime sources, we could see it from the above table. All of them are bottle neck problem as the above table indicated clearly the largest source of downtime was raised from Filler, crowner, bottle conveyor, date code, crate conveyor, bottle washer, mixer and unpacker respectively when speed of equipment is considered as one of the calculation parameters. But the most serious bottle necks are the following according to the above table. Filler, crowner, bottle conveyor and date code respectively. The Pareto diagram below also indicated clearly the largest source of downtime was raised from Filler, crowner, bottle conveyor, date code, crate conveyor, bottle washer, mixer and unpacker respectively. It was justified to say these machines have very high unplanned stoppage and causing a lot of production loose as it was shown from the above table and below Pareto graph .On the Pareto graph Y axis was represented by machineries and X axis was represented by performance loss or un planned stoppage. So there was significant effect to production time loss.

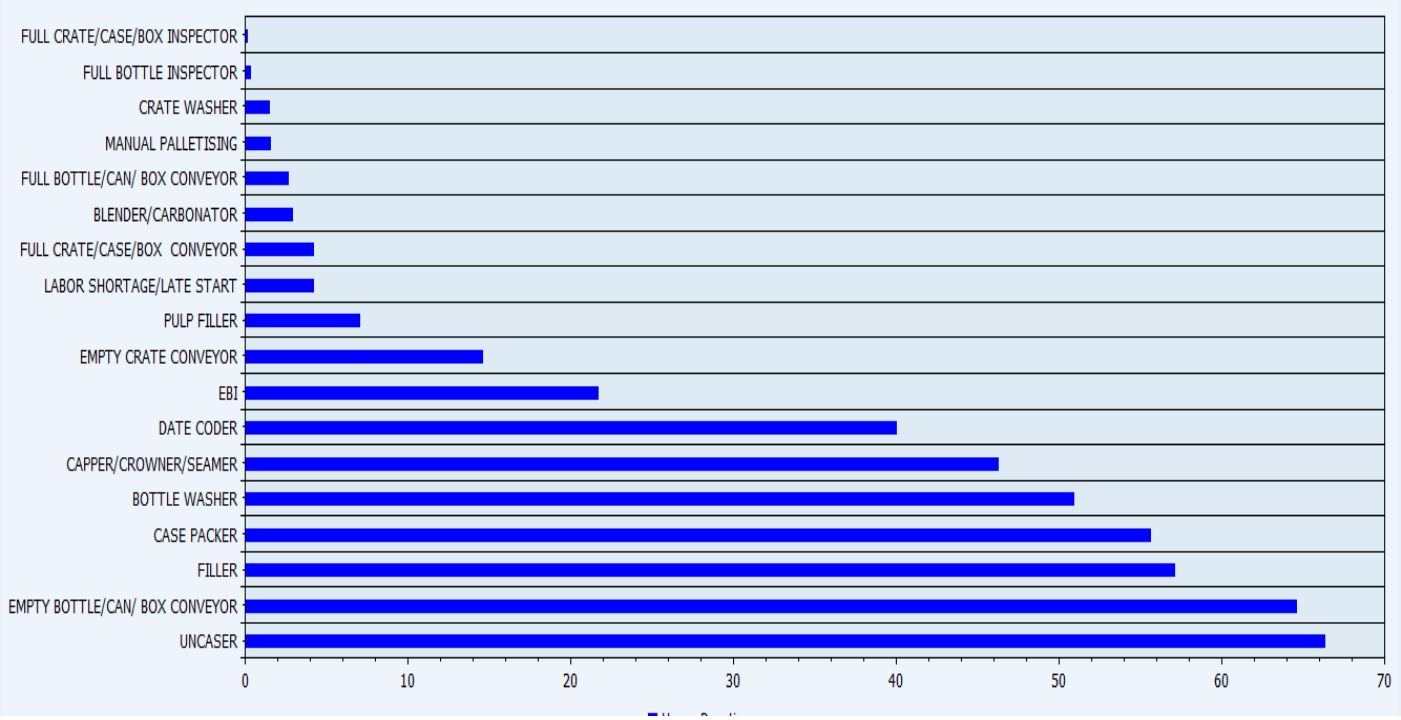


Figure 4.1pareto diagram on Equipment performance loss taken from SAP system.

Pareto diagram (figure 4.1) was illustrated clearly that above machines were all bottle neck problem but it's impossible to perform improvement project on all of then due to budget and time constrent.so as it was described on sample size selection by using stratified probability sampling to select some machineries to start improvement project on them. Filler, crowner, bottle conveyor and date code were selected machineries for this study. So improvement project work on maintenance was decided and done on these machineries area.

In addition, it was relevant to consider defective product which hold for inspection (HFI) spoilage as one indicator for choose equipment to be in the focus area of improvement project. Because, defects product causing hold for inspection (HFI) or spoilage are mostly related to equipment malfunction. Therefore, maintenance quality was contributed indirectly to HFI spoilage .the following hold for inspection (HFI) spoilage chart showed one year HFI spoilage data from 1/1/21 to 30/12/21. HFI data was collected from lines three. When compared HFI reasons, it was evident that it was raised from date code, filler, Full bottle inspector and crowner area respectively.

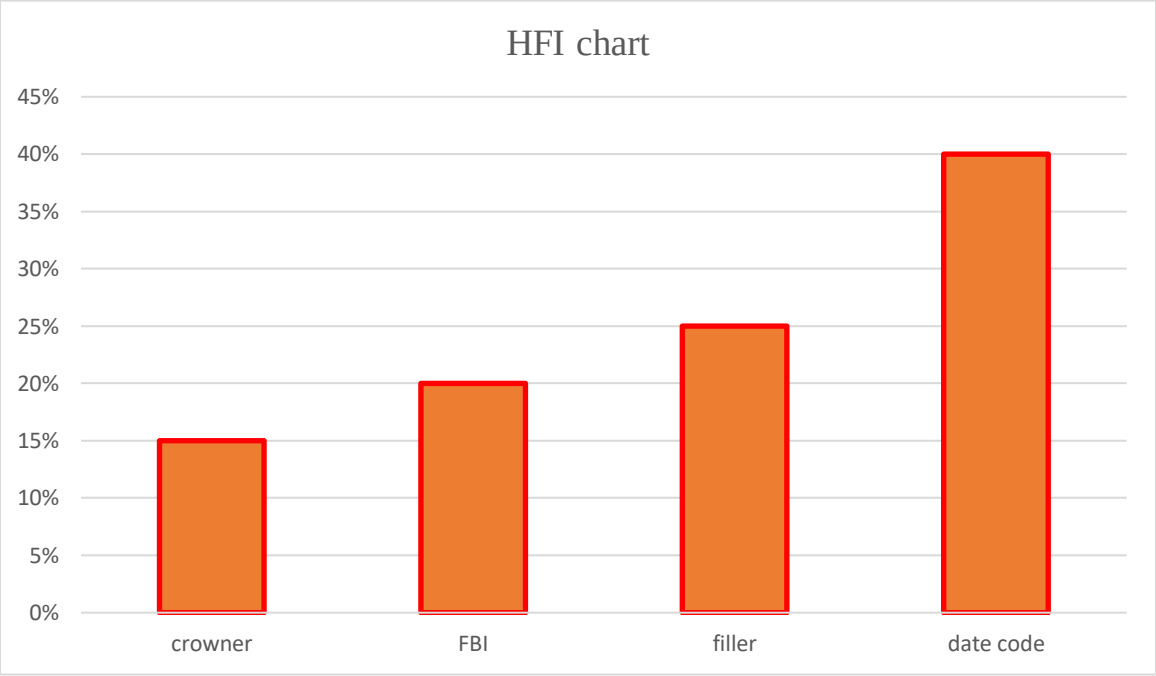


Figure 4.2 HFI Spoilage chart

When the above HFI spoilage graph was analyzed the defective product which hold for inspection was caused mostly by the above selected machineries. That means crowner machines contribute 1 5% for defective product, full bottle inspector(FBI) contribute about 20%,filler machine contribute about 25% and date code or printer machine contribute about 40% for defective product which hold for inspection respectively.so taking the above data into consideration the above selected machineries are contributing for quality issues or loss due to quality

issues. That means these machineries are in efficient and in effective .so this indicated that these machineries needs improvement during maintenance to bring them to the standard.

4.2.1 MEASURED OVERALL EQUIPMENT EFFECTIVENESS (OEE) AND ANALYSIS BEFORE IMPROVEMENT PROJECT

Over all equipment effectiveness (OEE) was described as the ratio between actual equipment output and the maximum equipment output in optimal manufacturing conditions (Almeanazel, 2010). Overall equipment effectiveness (OEE) is one of the parameter which is used to measure the quality of maintenance in the manufacturing industries.it comprise three essential parameters like availability, performance and quality.

For this study Overall equipment effectiveness (OEE) measurement data for one year (1/1/21 to 31/12/21) was taken from the case company information system before improvement work was started and analyzed. So it was seen that quality loss and machine availability were below target. Due to this Overall equipment effectiveness (OEE) measurement data actual was less than target as the case company information system showed on below table.

Table 4.2 OEE measurement

Overall equipment effectiveness (OEE)	OEE before improvement(actual)	OEE before improvement(planned)
	79%	81%
Quality loss	0.83%	$\leq 0.5\%$

When interpreted the above Overall equipment effectiveness (OEE) table we could state that there was significant visual quality lose and significant machine unavailability. However, OEE is slightly below the average before improvement project. As the figure visualized availability was dragging performance and spoilage which indicated that machine inefficiency was high and required need improvement to bring to the standard condition.

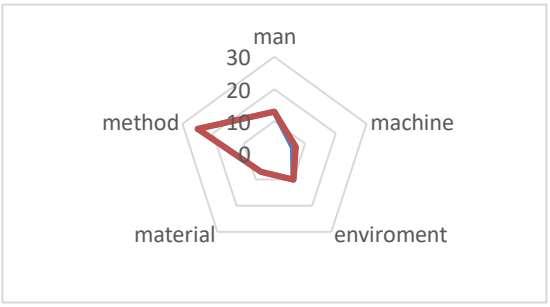
When downtime data and HFI spoilage data were analyzed together we could state that Filler, crowner, bottle conveyor and date code are contributed most of the downtime and HFI spoilage. Depending on the bottleneck analysis results the action research was targeted and implemented to Filler, crowner, bottle conveyor and date code respectively. To examine more closely these machineries related problems, focused group and root cause analysis team performed root cause analysis that causing break down or unplanned stoppage on these machineries. Root cause analysis was made by using tool called cause and effect diagram or fish bone diagram which found below. This Figure has the ability to show or to emphasize the most common and influential causes to issues out

of possible causes. According to this diagram the causes of the Problems were categorized in five different sections by FGD and root Couse analysis team and weighted. These problem categories are man, machine, method, material and environment. So root Couse analysis was focused on these five problem categories. Depending on focus group discussion and root Couse analysis team the most of the problems were allocated to method category. In the method category most influential causes are lack of proper preventive maintenance, lack of training, co-operation and communication between shifts and day staff. Some weight was also given for other problem category as the following. Inefficiency of maintenance system was mentioned also in man category and operator personal skills were emphasized. So When the weight given to the categories of problem were compared and put in decreasing order it become method, man, environment, material and machine. So depending on the focus group discussion and root Couse analysis result, improvement team was established and focused on the method category.

Table 4.3 problem category with their weight

S/no	**Problems category**	**Weight given by FGD and root Couse analyses team**
1	Method	25
2	Man	13
3	Environment	10
4	Material	7
5	Machine	6

As it was indicated on the above table, focus group discussion and root Couse analyses team were gave 25 weight for method categories. That means they gave priorities for this method problem categories .the method categories comprises a lot of possible causes that bring the above beak down and unplanned stoppage on these selected machineries. Method category comprise Different in adjustment in shift, Lack of proper maintenance, cleaning activity, Co-operation between the shift and routable work shop, Lack of proper training for operators, Lack of clear maintenance leadership, Maintenance system is not efficient and Change over procedure.



Man (13)	
1	Personal skill
2	Common sense
3	Communication
4	Difference level b/n qc in shift

Machine(6)	
1	Oil leakage
2	Dirty all time
3	Old fashion

Problem

Method(25)	
1	Different in adjustment in shift
2	Lack of proper maintenance
3	Cleaning activity
4	Co-operation b/n shift and routable work shop
5	Lack of proper training for operators
6	Lack of clear maintenance leadership
7	Maintenance system is not efficient
8	Change over procedure

Materials(7)	
1	Proper tools
2	Spare parts
3	Material variations

Environment(10)	
1	noisy
2	warm
3	Pressure from management
4	Working space
5	manning

Influence of cause
high
medium
low

Figure 4.4. Cause and effect diagram of possible causes of the problem

Overall, when putting together the above root Couse analysis data and evaluation of these machineries related problems and root causes, lack of proper maintenance was the most influential cause. So the improvement project decided on lack of proper maintenance by applying recommended action plan like solving spare parts issues, improving skill gap and changing mindset of maintainer, perform pre maintenance meeting, perform post maintenance meeting, tagging system and tag review meeting were recommended method for improvement project implementation by FGD and root Couse analysis team Since, it involves whole shifts and departments. Therefore, it increased the communication and co-operation between departments. According to improvement project team, improvement work implementation standard on Lack of proper maintenance was addressed first by operator involvement in proactive approach. However, if operator was not fix the problem, the tag was raised and it was assigned to line technicians and electricians. If the line technicians and electricians could not fix the problem, the tag was raised and it will be assigned to more skilled personnel. As such, the principles in the improvement project work or behind the tagging system should cover the issues raised in the root cause analysis. In such way improvement project was continued for two month on these selected machineries like filler, crowner, bottle conveyor and date code or printer.

SITUATION AFTER IMPROVEMENT PROJECT WORK HAVE BEEN IMPLEMENTED

After the improvement work have been done by improvement team the following data was again collected and analyzed again. So the situation after the improvement project implementation was evaluated on equipment performance loss, over all equipment effectiveness (OEE) measurement, machine availability measurement and maintenance activity measurement on these selected machineries as the following.

4.2.2 EQUIPMENT PERFORMANCE LOSS AFTER IMPROVEMENT

After the improvement work have been done by improvement team the data about equipment performance loss was collected and analyzed again. The following figure showed the equipment performance loss after improvement project done on the line three(3) filler, crowner, empty bottle conveyor and date code .So as the table 4.3 below showed these equipment unplanned stoppage or breakdown was significantly reduced compared with the data before improvement.

Table4.3 Equipment performance loss after improvement work

s/no	Machine names	Before	After
1	filler	53.8%	45%
2	crowner	43%	18%
3	Bottle conveyor	63%	17.5%
4	Date code	40%	5%

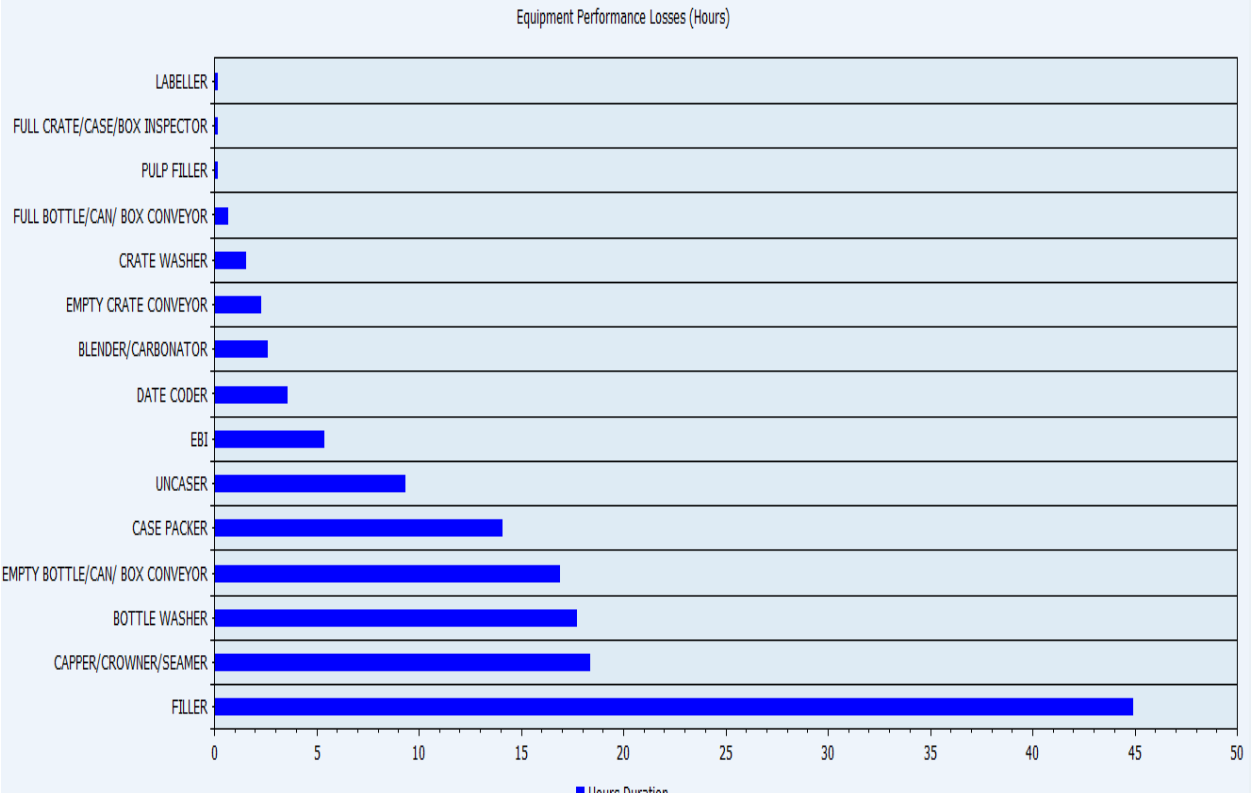


Figure 4.5 Equipment performance loss taken from SAP system.

When unplanned stoppage data for two month (1/03/22-31/04/22) after improvement project was analyzed, it shows that there is significant change on the break down on these selected machineries. That means Filler, crowner, bottle conveyor and date code. So it was justified to say that it was increased the production time by increasing machine availability. That means filler machine availability was increased by 8.8%,crowner machine availability was increased by 17%,bottle conveyor machine availability was increased by 45.5% and date code or printer machine availability was increased by 35% .in addition it reduced defective product which was hold for inspection(HFI) spoilage because, defects causing HFI spoilage are in indirectly related to equipment malfunction. So there was significant effect on the production by increased production time or by reducing break down and unplanned stoppage time.

4.2.3 MEASURED OVERALL EQUIPMENT EFFECTIVENESS (OEE) AND ANALYSIS AFTER IMPROVEMENT PROJECT WORK

Overall equipment effectiveness (OEE) is the product of machine availability, performance and quality. Measured Overall equipment effectiveness (OEE) measurement data for two month (1/03/22 to 31/04/22) was taken from the case company information system after improvement work was done and analyzed again.so we

have seen that machine availability was increased above target or planned. Due to this Operating equipment effectiveness (OEE) measurement data actual was increased more than target or planned operating equipment effectiveness (OEE) measured data as the case company information system showed on below table 4.4

Table4.4 OEE measurement after improvement project

Overall equipment effectiveness(OEE)	OEE before improvement	OEE after improvement
	81.50%	83.66%
Quality loss	0.5%	0.278%

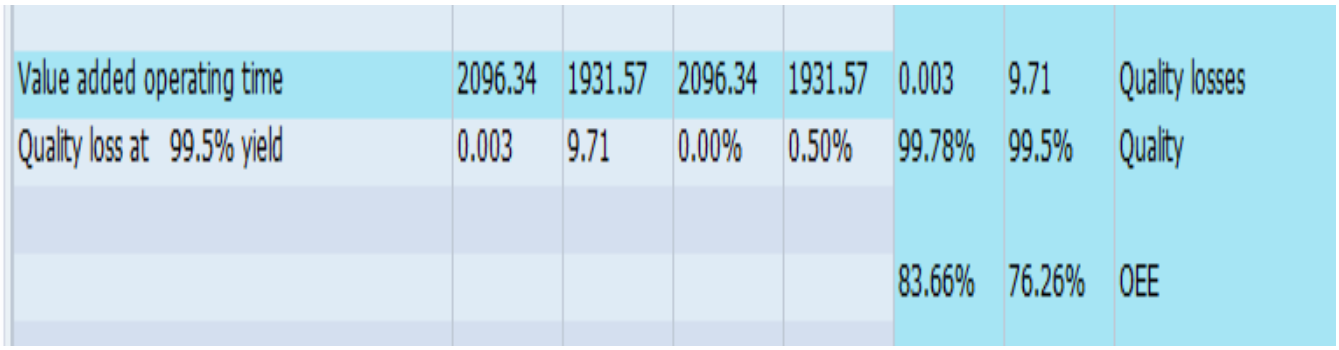


Figure 4.6 OEE chart taken from SAP system

When interpreted the overall OEE trend it was justified to say, that there was significant visual improvement from 81.50% to 83.66%. Which is 2.16% above the average before improvement project. As Availability increased it was released more production time and through that the performance has increased as well. The performance trend seems to be more stable after improvement project work was implemented in the line three.

In addition When the above Overall equipment effectiveness (OEE) trend was interpreted we could state that there was significant visual effect on quality lose reduction or HFI spoilage reduction from 0.5% to 0.278% and significant machine effectiveness was increased, OEE was improved above the target value after improvement project. So it was justified to say that it increased the production time by increasing machine availability and machine effectiveness or machine efficiency. OEE comprise machine availability, performance and quality. That means when OEE was improved directly machine availability and machine performance was improved positively while defective product reduction or quality issue was effected negatively. So the following key performance indicator (KIP) graph was described OEE as the product of machine availability, performance and quality

When interpreted the overall OEE trend we could state that there was significant visual improvement from 81.50% to 83.66%. Which is 2.16% above the average before improvement project. As Availability increased it was released more production time and through that the performance has increased as well. The performance trend seems to be more stable after improvement project work was implemented.

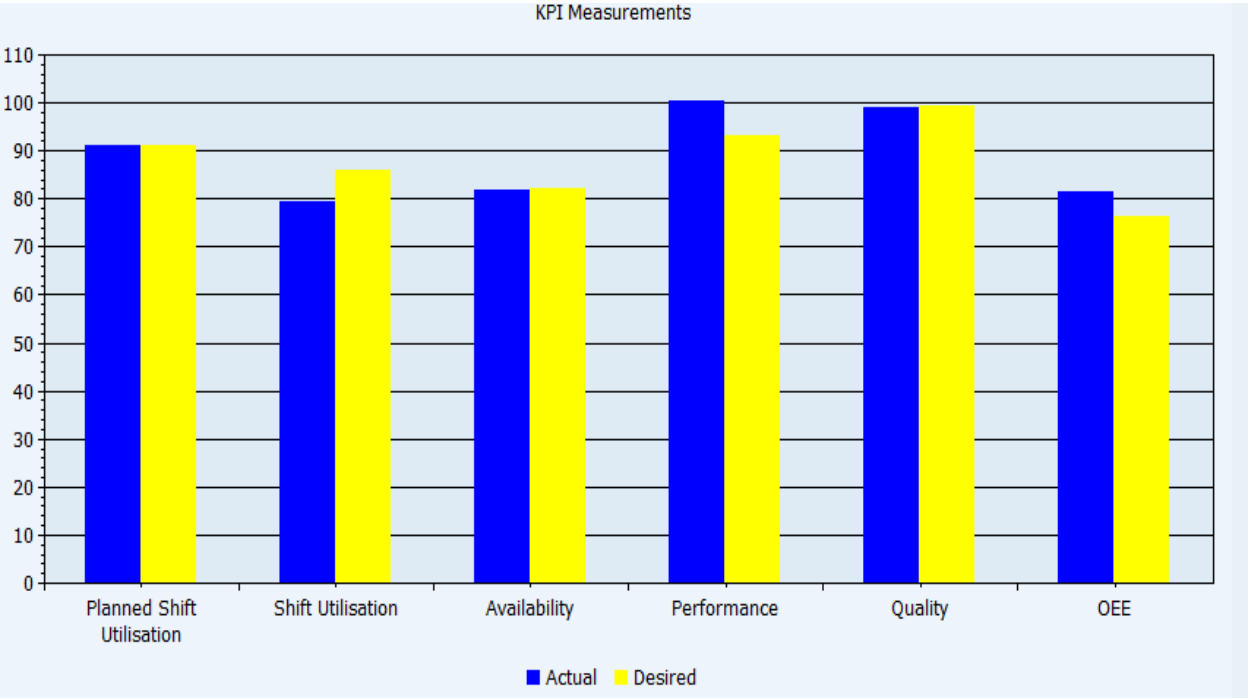


Figure 4.7 KPI measurement Line 3 taken from SAP system

Above KPI graph was showing performance increased by 10%, availability increased by 2.16 % from 81.50% to 83.66%, which was significant change when translated to amount of production time available.

When calculated for example daily availability improvement average per day or in 24 hour, it was 1440min * 0.0216= 31.1 minute. When calculated to actual bottle produced it means 31.1 min * rated speed 600 BPM = 18,662.bottles.

When calculating the production improvement figures together and forecasting the average improvement based on the data acquired for the time period of one year per line, Daily improvement (18662 bottles) * (365 days) = 6811630 bottles or 6811630 bottle/ 600BPM (rated speed) = 11352.7 minute or 7.88 days available for production. This results from line three was showing that availability improvement is having a positive impact to overall equipment's effectiveness (OEE). Average OEE increased from 81.50 % to 83.66%.

4.2.4 MAINTENANCE ACTIVITY

Maintenance Activity is essential for successful maintenance to notice abnormalities before bigger breakdown appears. Therefore, maintenance tasks or activities was chosen as one sub-indicator to see how much system changed and activated maintenance department. Earlier maintenance activity data was collected and measured from existing maintenance system.in addition the interview was done on eight concerned case company employees which comprises operators and maintenance team .again concerning with maintenance activity after improvement project and its effectiveness, data was collected from SAP system and interview was done on eight concerned case company's employees which comprises operators and maintenance team. Around 90% of interviewees were replied it was improved and should have consistency while 10% interviewees were replied it's good and still it needs improvement. Concerning Raised maintenance tasks data for these machineries were collected from one year 1/1/2021 to 31/12/ 2021 before improvement project and compared to activity generated with maintenance activity generated after improvement project especially after the tagging system implementation. Figure 4.8 shows that trend of noticed abnormalities has decreased drastically after tagging system implemented from 1/03/ 2022 to 31/04/22.we could state that tagging system has improved identification of abnormalities on these machineries area. Average of tasks raised increased at least twice to situation before tagging system implementation. This shows the maintenance effectiveness was also increased significantly.

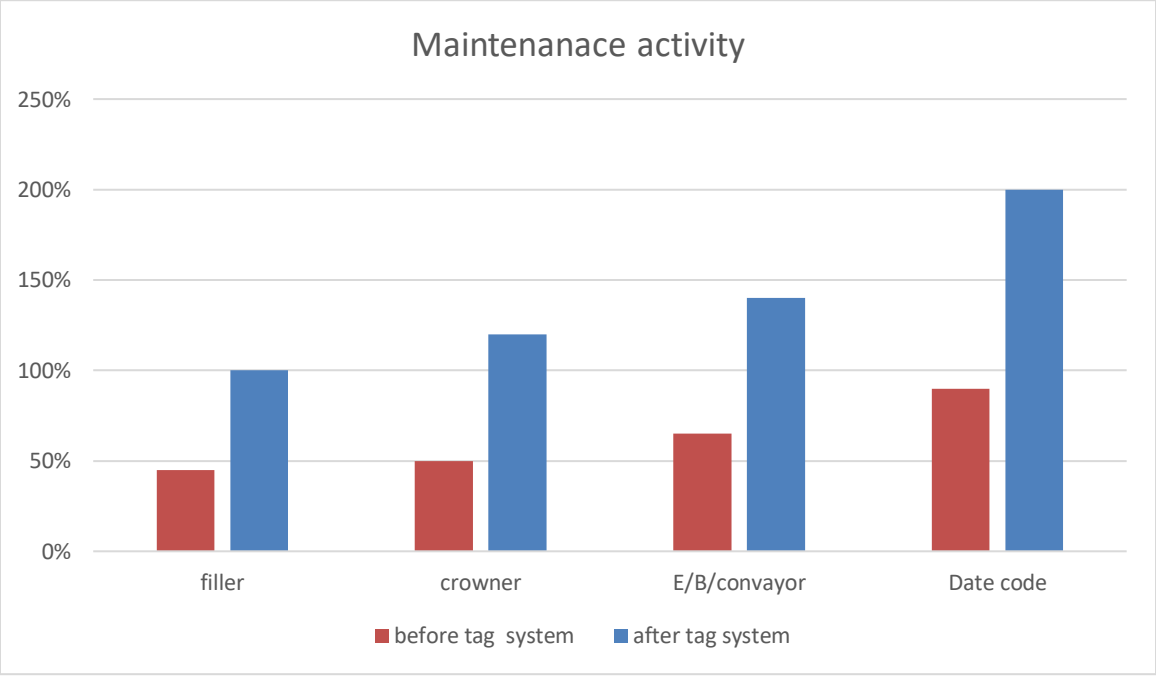
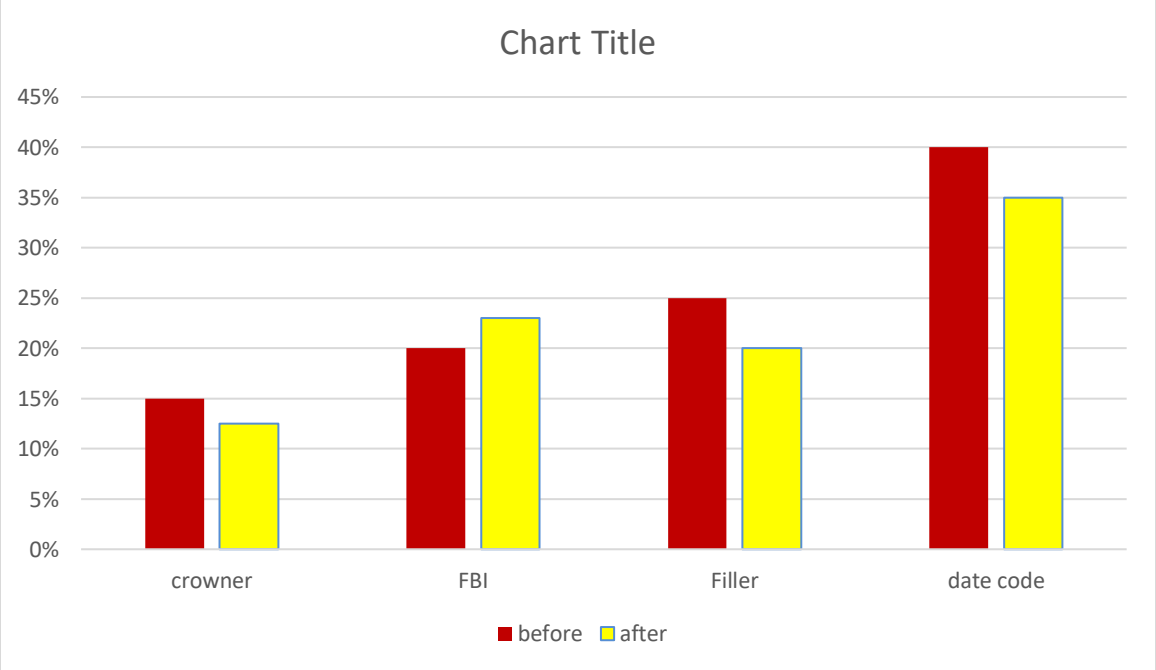


Figure 4.8 maintenance activity

4.3 DESCRIPTION OF SPECIFIC OBJECTIVES

4.3.1 QUALITY IMPROVEMENT OR REDUCE DEFECT PRODUCT HOLD FOR INSPECTION

As it was identified during bottle neck problem identification time a lot of product was hold for inspection due to lack of standard quality. This defect was largely related to malfunction of some production machineries like filler, crowner, FBI and date code before improvement project implementation. Therefore, maintenance actions are contributed indirectly to quality issue or HFI spoilage .So the following HFI spoilage chart showed one year HFI spoilage data from 1/1/21 to 30/12/21 which painted by red color and compare with the data collected and analyzed after improvement project was implemented which painted with yellow color. As this chart showed around 40% of product hold for inspection was caused by date code or printer, 25% was caused by filler, 20 % was caused by FBI and 15% was caused by crowner before implementation of improvement project. So after improvement work was done it was improved as it was described on the following chart. That means the defective product hold for inspection (HFI) was reduced on filler by 5%, on crowner by 2.5%, and on date code by 5%.



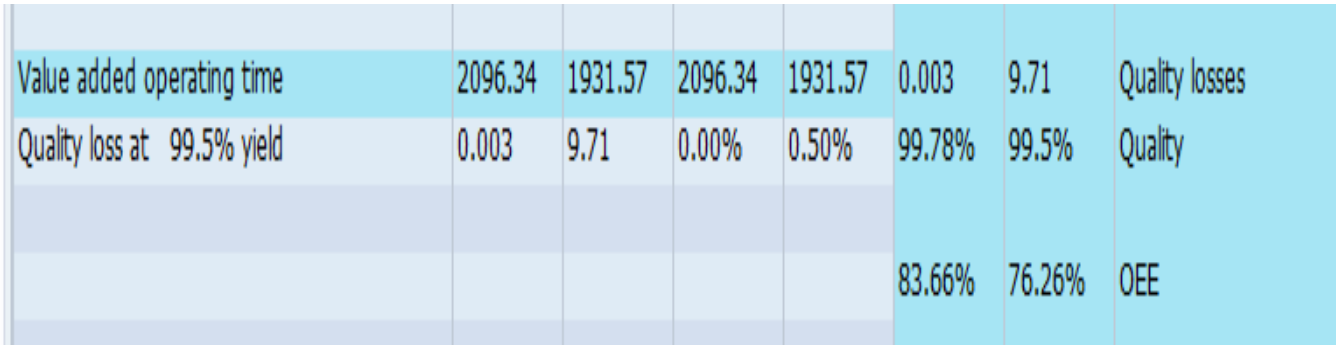
As the data collected after improvement project performed from 1/03/ 2022 to 31/04/22 indicated the defect product which is hold for inspection by quality control departments was decreased significantly. That means defect product caused by crowner decreased by 2.5%, defect product caused by filler was decreased by5% and the defect product caused by date code was reduced by 5 % as it was indicated from the above HFI chart. Due to this rework due to quality issues like sorting, scrapping and ware house reservation were reduced drastically.

4.3.2 IMPROVE EQUIPMENT EFFICIENCY AND AVAILABILITY

Operational equipment effectiveness (OEE) is the product of availability, performance and quality. So Operational equipment effectiveness (OEE) measurement data for two month (1/03/22 to 31/04/22) which was taken from the case company information system (SAP system) after improvement work was done and analyzed again was indicated that, there is improvement on the machine availability and machine's effeciency.So it was seen that machine availability was increased above target or planned by 2.16%. Due to this OEE measurement data actual was increased more than target or planned OEE measured data as the case company information system showed on below table 4.5

Table4.5 OEE measurement

Operating equipment effectiveness(OEE)	OEE before improvement	OEE after improvement
	81.50%	83.66%
Quality loss	0.5%	0.278%



Value added operating time	2096.34	1931.57	2096.34	1931.57	0.003	9.71	Quality losses
Quality loss at 99.5% yield	0.003	9.71	0.00%	0.50%	99.78%	99.5%	Quality
					83.66%	76.26%	OEE

Figure 4.6 OEE chart taken from SAP

When interpreted the above over all equipment effectiveness (OEE) trend we could state that there is significant visual quality lose reduction from 0.5% to 0.278% due to the improved machine efficiency and significant machine availability by 2.16%.overall equipment effectiveness(OEE) was improved above the target value after improvement project. As the figure visualized availability was increased. So it was justified to say that it was increased the production time by increased machine availability and reduced defective product which is hold for inspection by increased equipment efficiency and effectiveness.

When interpreting the overall OEE trend we could state that there was significant visual improvement from 81.50% to 83.66%. Which is 2.16% above the average data before improvement project. As the machine

availability increases it will release more production time and through that the performance could have potential to increase as well. The performance trend seems to be more stable after improvement project done. Especially after tagging system implementation.

4.3.3 INCREASE PRODUCTIVITY

As the following key performance indicator (KPI) measurement graph showed productivity was increased by increased production time, increased performance and reduced quality defect product which is mostly related to the malfunction of machineries. So the following KPI graph showed the comparison between data after improvement project which was painted with blue color or actual and planned data which was painted by yellow color. This graph was tried to show and compare actual and desired or planned values of KPI of line three like planned shift utilization, machine availability, performance, quality and overall equipment effectiveness (OEE).

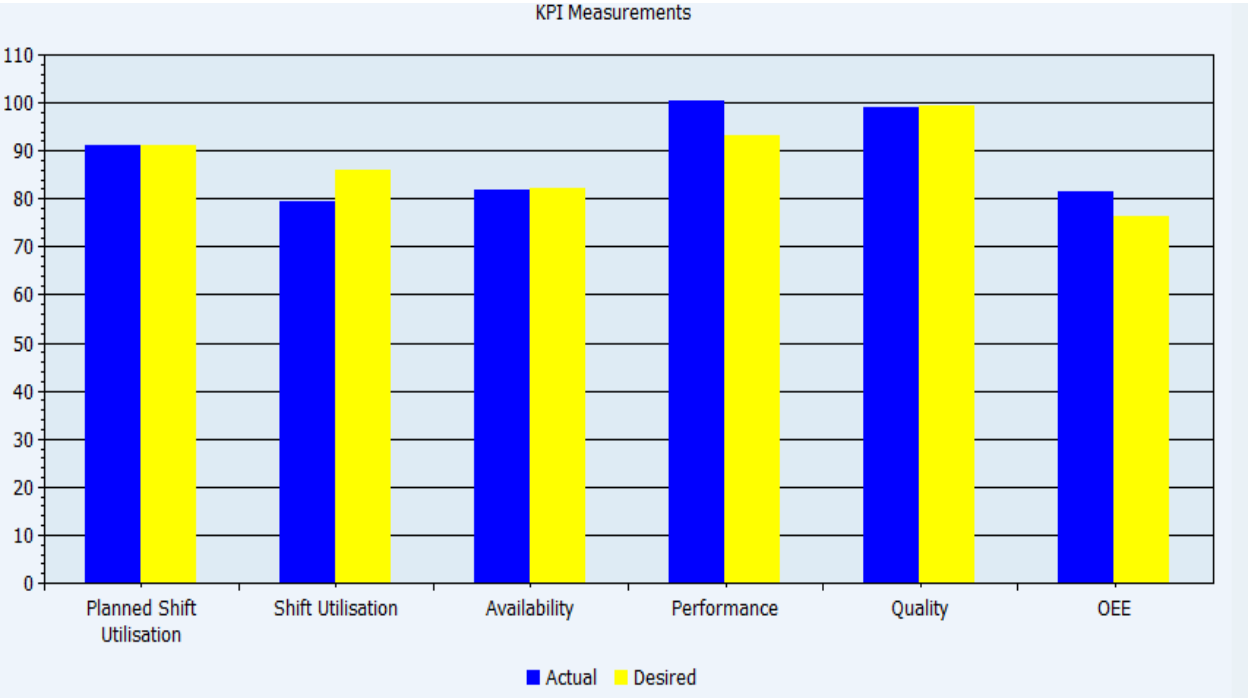


Figure 4.7 KPI measurement Line 3

Above KPI graph was showed performance was increased by 10%, machine availability was equal with desired value and overall equipment effectiveness was increased by 2.16 % from 81.50% to 83.66%, which was significant change when translated to amount of production time available. When calculating for example daily availability improvement average per day or in 24 hour, it was 1440min * 0.0216= 31.1 minute. When calculated to actual bottle produced it means 31.1 min * rated speed 600 BPM = 18,662.bottles.

When calculating the production improvement figures together and forecasting the average improvement based on the data acquired for the time period of one year per line. That means Line 3 Daily improvement (18662 bottles) * (365 days) = 6811630 bottles or 6811630 bottle/ 600BPM (rated speed) = 11352.7 minute or 7.88 days available for production. This results from line three is showing that machine availability improvement is having a positive impact to overall equipment effectiveness (OEE). So Productivity was increased by increasing production time by 7.88days or by reducing unplanned time or break down by 7.88days on these selected machineries.

4.3.4 FIND APPROPRIATE MAINTENANCE METHOD

Appropriate maintenance method is essential for one manufacturing company to be profitable. Because it's one main strategy for the manufacturing and maintenance department. Appropriate maintenance method is essential for successful maintenance to notice abnormalities before bigger breakdown appears. Therefore, raising maintenance tasks or activities was chosen as one sub-indicator to see how much system changed and activated maintenance department. maintenance activity data was collected and measured from existing maintenance system and compared with data after improvement project implemantations.in addition the interview was done on eight concerned case company employees which comprises operators and maintenance team again concerning with maintenance activity after improvements and its effectiveness.so six(6) participant or 90% were replied it was improved and should have consistency while 10% were replied it's good and still it needs improvement. In addition Raised maintenance tasks data for these machineries were collected for one year (1/1/2021 to 31/12/ 2021) and compared to activity generated in the two month after improvement project implementation or with the tagging system. Figure 4.8 shows that trend of noticed abnormalities has decreased drastically after tagging system implemented from 1/03/ 2022 to 31/04/22.we could state that tagging system has improved identification of abnormalities on these machineries area. Average of tasks raised increased at least twice to situation before tagging system implementation. This shows the maintenance effectiveness was also increased significantly. How ever since this project will continue for one year depending on the request of case company the end result will decide the appropriateness of the improved maintenance method. However as it was shown on the following figure maintenance activity after improvement project or tagging system was better than before tagging system implantation on the selected machineries even if the data collected after improvement project implementation or tagging system has only two month time period. This indicted that the maintenance method applied during improvement project is appropriate maintenance method even if it needs further study to model it.

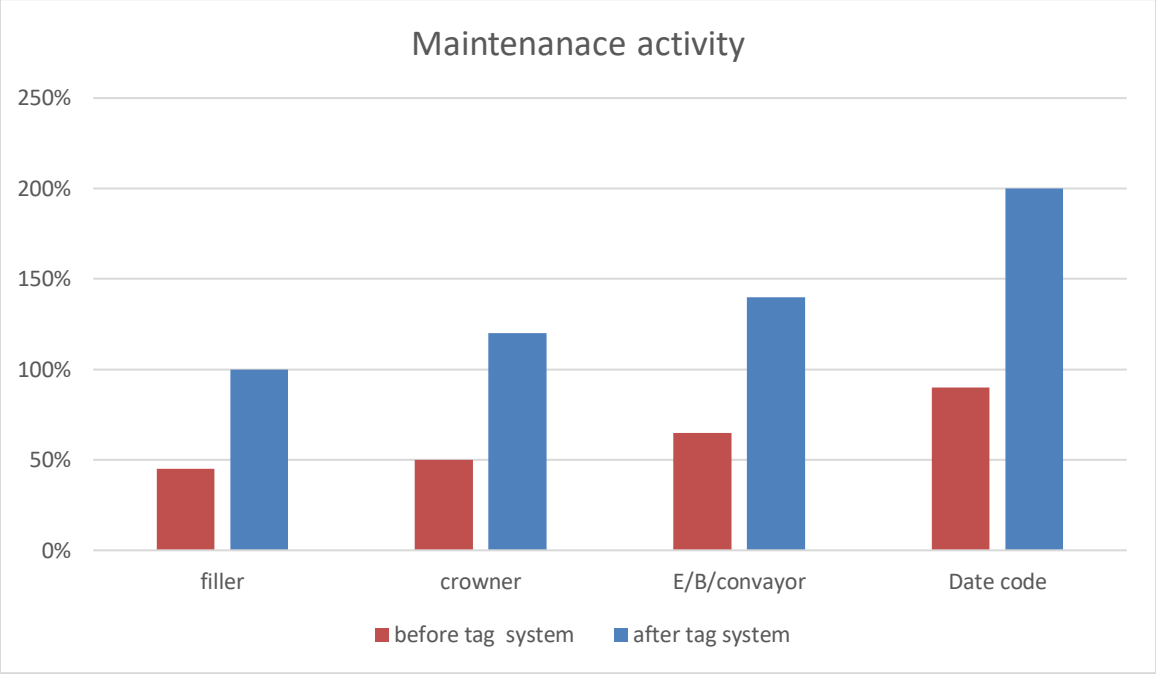


Figure 4.9 maintenance activity

When the above maintenance activity graph was interpreted the maintenance activity before maintenance project implementation on the selected machineries like filler, crowner or capper, conveyor and date code which was painted red was very small compared with the maintenance activity performed after implementation of improvement project which was painted with blue colour.so this improvement was due to the appropriate maintenance method which applied during improvement project implementation. Especially tagging system was very successful in the indication of abnormality during performing inspection. However it needs further study to model this maintenance method as new maintenance model for the manufacturing organization. That means it needs long time to test this new maintenance method.

CHAPTER FIVE

5. SUMMARY, CONCLUSION AND RECOMMENDATION

This final chapter includes three sub titles, first title started with Discussion and conclusions which summarized the findings and results of the study. In addition, it also highlighted research questions and challenges before conducting the study. Situation after the improvement project was analyzed as well. Second title evaluated the validity and the reliability of the study in the changing manufacturing environment with some uncertainty factors in the facility and process. Third title was the final title of this thesis. It was highlighted possible topics and phenomena for further study.

5.1 CONCLUSIONS AND DISCUSSION

The original challenge when starting the study was to get more production time by avoiding unplanned stops or breakdowns and to nourish the communication about the maintenance actions. Supporting this challenge to be solved, research questions were positioned as follows.

- What is current maintenance strategy of the case company?
- What are the case company bottleneck problems concerning with maintenance?
- What are the key area for improvement concerning with maintenance?
- How maintenance should be improved in the current situation?

The research results found out that key area for improvement are filler, crowner, empty bottle conveyor and date code or printer which were created frequently unplanned stoppage and affected the production. Other Problematic issues like lack of co-operation, communication and lack of preventive maintenance were mentioned in the root cause analysis by the improvement team which was established for the project. Based on the root Cause analysis, selected method for improving these earlier mentioned issues were implemented. Solving spare parts issues, improving skill gap and change maid set of maintainers, perform Pre maintenance meeting, perform post maintenance meeting, perform tag review meeting and tagging system was implemented. Tagging system method was originated from Milton Keynes, England beverage manufacturing plant, which is one the oldest plants in Ball Corporation. System was slightly modified to respond in better way to the situation in coca cola Addis Ababa plant and implemented according to six sigma DMAIC roadmap. The theory of tagging system was deducted to practice from TPM approaches like, focused improvement and autonomous maintenance. The holistic view to improvement cycle of implementation was based on continuous improvement philosophy. Situation was evaluated as overall equipment effectiveness (OEE) measurement data was taken before and after improvement

project was implemented on selected machineries. To see actual implications by factors, like performance of the line, machine availability and product quality during the two month evaluation period, overall equipment availability (OEE) result was positively increased. Significant improvement was noticed especially in the equipment availability factor, which is result of improved production time of machine. Availability factor was measured from the total time available after unplanned stops, small stops and lower speeds. Therefore it could be said that equipment was able to run rated speed with smaller amount of unplanned stops. So improved maintenance and effective maintenance which is independent variable has direct positive impact on the dependent variable like overall equipment effectiveness (OEE) and it has also indirect positive impact on other dependent variable like decrease defect product or reduce HFI spoilage, reduce spare part cost and increase productivity. From the author's point of view in project manager position, it was great situation for learned how project work was handled even if it is small project. However, there was not that big emphasis on project work. Since, there was great amount of attention focused on company's maintenance activities, which showed how influential maintenance to manufacturing company's business result. Without proper maintenance, equipment condition was degrade and cause huge expenses to company in the future. Quite often maintenance is separate department which is rarely in focus. However, culture change towards more proactive maintenance activities would be beneficial to many companies. Significant observation from this project was that, by very small budget, it is possible to obtain great benefits by improving maintenance activities even in short period. By involving whole manufacturing competency to change, it was create new attitudes to saw that maintenance is actually part of all core processes in manufacturing environment.

5.1.1 VALIDITY AND RELIABILITY

Validity defines how well chosen indicator is applied to the case or how well the phenomenon can be measured by using it. Study can be stated to be valid when it is focus to right group and questions are correctly positioned. Validity also shows how well researcher performed. If there is no new or correct information available after study, it is not valid.

Reliability indicates that if research method is correct. It also measures if study is easily repeated and whether the results would be same. When study was repeated in same circumstances, the results should be same, if not then study is not reliable and results are random. (Hiltunen, 2009) The validity of the study is based on the indicators and equipment chosen under study. Relation between maintenance, equipment and overall equipment effectiveness (OEE) is immediate. Therefore, it was justifiable to say that study is valid. The reliability of study results can be evaluated from different angles. Those information systems, where data was collected, are reliable and possibility for acquiring inaccurate information is almost zero. However, the data was collected only for two month time period, which is not sufficient. Nevertheless, overall equipment effectiveness as improvement

indicator is commonly used in similar TPM projects. Overall equipment effectiveness (OEE) result is giving reliable data as long as data is collected in the same way every time. Data analysis was performed similarly as well. There was no room for human errors since information systems are collecting automated data from equipment operation. Based on this information we could say that study was reliable from the two months of time period result observation.

5.2 LIMITATIONS OF THE STUDY

Those information systems, where data was collected, are reliable and possibility for acquiring inaccurate information is almost zero. However, Data after improvement was collected and analyzed based on only two month time period and its reliability was based on this two month data. In addition there are factors like production planning was effecting to changeover times and then there is slightly space for reliability improvement.

5.3 RECOMMENDATION

- The finding of the study is very important for the case company.so they should take in to consideration and ensure the continuity of the improved maintenance procedure and tagging system.
- They should expand this study's finding on other machineries area and check the results.
- They should focus on the further study which is very important and help them in the modelling of improved maintenance method.

REFERENCES

Electronic References

Advanced Business Management Solutions(ABSM), 2016, Total Productive Maintenance TPM, viewed 27 August 2016, Almeanazel, O.T. 2010,'Total Productive Maintenance Review and Overall Equipment Effectiveness Measurement', Jordan Journal of Mechanical and Industrial Engineering, vol.4, no.4, pp.517-522, viewed 25 August 2016, http://jjmie.hu.edu.jo/files/v4n4/JJMIE-129-08_Revised(11)/JJMIE-129-08_modified.pdf

Artiba, A. & Riane, F. 2005, Maintenance strategies and reliability optimization', Journal of Quality in Maintenance Engineering, vol.11, no.2, viewed 4 October 2016, http://site.ebrary.com.aineistot.lamk.fi/lib/lamk/reader action? Doc ID=10085 637

Ball Corporation, 2016,'Overview', viewed 22 July 2016, http://www.ball.com/eu/about-ball/overview

Bhuiyan, N., & Baghel, A. 2005,'An overview of continuous improvement: from the past to the present', The Emerald Research Register: Mechanical and Industrial Engineering, Concordia University, vol.43, no.5, viewed 27 September 2016, http://www.iem.unifei.edu.br/turrioni/PosGraduacao/PQM07/ Continuous improvement aula 4_e_5/0010430509%20melhoria%20continua.pdf

Gitachu, D. 2016, 'TPM Pillars – Eight Pillars of Total Productive Maintenance', Tough Nickel, viewed 8 August 2016,https://toughnickel.com/industries/whatistotalproductivemaintenancedefinitiontpm-pillars-tools#mod_27041593

Hayes, R.H. 1981,'Why Japanese Factories Work', Harvard Business Review, viewed 20 June 2016, https://hbr.org/1981/07/why Japanese factories-work

Hiltunen, L. 2009,'Validiteetti ja reliabiliteetti', Jyvaskyla Yliopisto, viewed 24 November 2016, http://www.mit.jyu.fi/ope/kurssit/Graduryhma/PDFt/validius_ja_reliabiliteetti .pdf

ISixSigma, 2016,'The Fundamentals of Cause-and-effect Diagrams', viewed 27 September 2016, https://www.isixsigma.com/toolstemplates/cause-effect/the-fundamentals of cause and effect-akafishbone-diagrams/

ISixSigma, 2016,'Six Sigma DMAIC Roadmap, viewed 15 September 2016, https://www.isixsigma.com/newto-six-sigma/dmaic/six-sigma-dmaicroadmap/

Karthick, R., Kumar, G.S., & Vivekprabhu, M. 2014, 'Optimization of Overall Equipment Effectiveness in A Manufacturing System', International Journal of Innovative Research in Science, Engineering and Technology, vol.3, no.3, viewed 28 August 2016, https://www.researchgate.net/publication/285586296_Optimization_of_Overall Equipment Effectiveness in a Manufacturing System

Korkut, D.S., Cakicier, N., Erdinler, E.S., Ulay, G. & Dogan, A.M. 2009,'5S activities and its application at a sample company', African Journal of Biotechnology, vol.8, no.8, pp. 1720-1728, viewed 4 September 2016, http://search.proquest.com.aineistot.lamk.fi/docview/1658766790?accounti d=16407

MoreSteam, 2016,'Pareto Chart (Manufacturing Example)', viewed 6 September 2016, https://www.moresteam.com/toolbox/pareto-chartmanufacturing.cfm

Porter, M.E. 1996,'What is strategy?', Harvard Business Review, viewed 1 July 2016, https://hbr.org/1996/11/what-is-strategy

Power, B. 2010,'When Is Process Improvement Strategically Important', Harvard Business Review, viewed 25 September 2016, https://hbr.org/2010/10/i-admit-im-a-process

Rexam PLC. 2016b, 'Media - Facts & figures', viewed 29 February 2016, http://www.rexam.com/index.asp?pageid=420 Rexam, 2016a, 'About us - The Rexam story', viewed 29 February 2016, http://www.rexam.com/index.asp?pageid=604

Rubrich, L. 2016,'TPM is most difficult of all lean tools to implement', Noria Corporation – Reliable plant, viewed 27 June 2016, http://www.reliableplant.com/Read/26210/tpm-lean-implement

Sharma, A.K. 2012,'Manufacturing performance and evolution of TPM', International Journal of Engineering Science and Technology (IJEST), viewed 25 July 2016, http://www.ijest.info/docs/IJEST12-04-03-012.pdf

Sokovic. M., Pavletic, D., & Kern Pipan, K. 2010,'Quality Improvement Methodologies – PDCA Cycle, Radar Matrix, DMAIC and DFSS', Journal of Achievements in Material and Manufacturing Engineering, vol.43 no.1, viewed 24 September 2016, http://w.journalamme.org/papers_vol43_1/43155.pdf

Suomen Palautuspakkaus Oy, 2016, 'Juomatölkin historiaa', PALPA, viewed 22 April 2016, http://pantilliset.fi/perustietoa/juomatolkin-historiaa/

Tappura, S. 2009, Toimintatutkimus', Tampereen Teknillinen Yliopisto – Teollisuustalous – Turvallisuuden johtaminen jasuunnittelu, viewed 25 October 2016, http://matriisi.ee.tut.fi/hmopetus/hmjatkoopintosemma/2008/Tappura_Toimintatutkimus090109.pdf

The Deming Institute, 2016,'The Deming Cycle', viewed 28 September 2016, https://www.deming.org/theman/theories/pdacycle

Visy Beverage Cans, 2016,'Beverage Can Manufacturing, viewed 28 October 2016, http://www.abmsindia.com/TPM.html https://static1.squarespace.com/static/534fe620e4b0337f7ff5c5da/t/55e63b25e4b02a211f803c45/1441151853362/Beverage+can+manufacturing+diagram

Vorne Industries Incorporation (OEE.com), 2016,'Calculate OEE', viewed 26 August 2016, http://www.oee.com/calculating-oee.html Vorne Industries Incorporation (OEE.com), 2016,'Six Big Losses', viewed 26 August 2016, http:// www.oee-six-big-losses.html.

Written references

Evans, J.R, & Lindsay, W.M. (2015) an Introduction to Six Sigma & Process Improvement. 2nd Ed. Stamford, CT. Cengage Learning

Koch, R. (2008) The 80/20 Principle: The Secret to Achieving More with Less. 2nd Ed. New York, US. The Doubleday Publishing Group

Laine, H.S. (2010) Tehokas kunnossapito: Tuottavuutta käynnissäpidolla. 1st Ed. Kerava.: KP-Media Oy

Levitt, J. (2011) Complete Guide to Preventive and Predictive Maintenance. 2nd Ed. New York, NY: Industrial Press Inc.

Mobley, R.K. (2002) Plant Engineering: An Introduction to Predictive Maintenance. Saint Louis, US: Butterworth-Heinemann. ProQuest ebrary

Mobley, R.K. (2011) Plant Engineering: Maintenance Fundamentals. Saint Louis, US; Butterworth-Heinemann. ProQuest ebrar

Nieminen, H (2016) Improving maintenance in high volume manufacturing

APPENDIX

APPENDIX A

TOTAL PRODUCTIVE MAINTENANCE (TPM)

TPM is holistic view of the impacts of maintenance in production. TPM means that whole organization is making commitment for sustain, develop and maintain manufacturing capacity. One of the leading principles in TPM is that every employee participates. TPM is basing on teamwork and for managers especially coaching these teams to top performance. When creating favorable environment for motivation growth we can achieve highly motivated employees playing in our team. (Laine 2010) Total Productive Maintenance (TPM) has been developed in Japan and spread across the world by Japan Institute of Plant Maintenance. There are several similar development methods and tools with TPM like TQM (Total Quality Management) and JIT (Just-In-Time) which are supporting each other. (Tuominen, 2010). First, Nippondenso a Japanese component manufacturer for automotive industry started using TPM in the year 1961. Actually, name was first introduced as 'Productive Maintenance with Total Employee Participation' which is quite self-explanatory term. Soon, TPM was implemented also by Toyota and other Japanese manufacturing companies. At latest TPM spread also to rest of the world in 1990's when competition started to demand quality improvement program implementations like TQM. (Sharma 2012) TPM relies on five different sections, maintaining quality, productive maintenance, manufacturing technique, cleanliness & order and highly skilled employees. However, Japan Institute of Plant Maintenance defines that TPM should be implemented according to following minimum procedures. 1. Set goals which will maximize equipment effectiveness 2. Create sustainable productive maintenance system 3. Engage all departments – planning, production, quality, maintenance. 4. Involve whole organization in TPM program 5. Create focus groups to motivate and support maintenance TPM is way of thinking that maintenance is everywhere, it is not anymore limited to corrective or preventive maintenance actions. In the definition of maintenance according to the TPM belongs that maintenance is emphasized in relation between company's overall income and cost structure. Maintenance should be element that increases gross productivity. Maintenance is always included as part of continuous improvement strategy and as part of company's main strategy. Daily maintenance agenda is not enough when goal is to get high machinery utilization rate and productivity figures. Certain elements should be taken into consideration according to TPM to achieve the goals set, these elements are also called as pillars

APPENDIX B

OVERALLEQUIPMENTEFFECTIVENESS

six big losses in TPM are strictly related to ideal performance and zero loss methodology and OEE calculation is way to measure how successfully losses are controlled. OEE could be described as the ratio between actual equipment output and the maximum equipment output in optimal manufacturing conditions. In manufacturing industry OEE is viewed as key performance measure considering all kind of processes and equipment. In the year 1988 Nakajima introduced OEE as TPM performance measurement system which focuses into manufacturing equipment by offering clear overall metric. In todays' manufacturing world it has become essential tool for productivity measurement. Traditional metrics are insufficient when handling problems and identifying required improvements for increasing productivity. The accuracy of OEE is depending on the quality of collected data. Overall equipment effectiveness is simple way to measure current status of production. Higher productivity could be achieved by utilization of man, machines, material and methods. OEE consists three essential parameters, Availability (A), Performance (P) and Quality (Q). Figure below indicates how traditional six big losses are connected to OEE calculation. Recommended six big losses are rephrased to more explanatory form from traditional**.**

Overall Equipment Effectiveness	Recommended Six Big Losses	Traditional Six Big Losses
Availability Loss	Unplanned Stops	Equipment Failure
	Planned Stops	Setup and Adjustments
Performance Loss	Small Stops	Idling and Minor Stops
	Slow Cycles	Reduced Speed
Quality Loss	Production Rejects	Process Defects
	Startup Rejects	Reduced Yield
OEE	Fully Productive Time	Valuable Operating Time

OEE calculation is done by following pattern which is presented in figure below

OEE Calculation (Vorne Industries Incorporation 2016)

Appendix C

Key informant interview

The following are informant interview question used for structural interview

1- Why the machineries are creating unplanned down time frequently?

2-Is the planned maintenance performed in standard condition? If yes how? If no why?

3-Are all technicians and electricians have full information about planned maintenance? If yes how? If no why?

4- Are all machineries working smoothly or start smoothly after planned maintenance done? If no why?

5- Are all technicians and electricians know their daily routine work and how they perform it?

6- Is defect product hold for inspection increases or decreases after planned maintenance? If increased why?

7- Is OEE actual data equal with target or planned OEE data? If no why?

8-Is line three deliver planned volume monthly and yearly? If no why?

9-Is machine is always available when production required? If no why?

10- Is spare issue is always problem for unplanned stoppage? If yes why?