CORRECTIVE MAINTENANCE PRACTICES AND OPERATIONAL PERFORMANCE OF MANUFACTURING FIRMS LISTED IN THE NAIROBI SECURITIES EXCHANGE

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DECLARATION

This research project is my original work and has never been submitted to any other university for assessment or award of a degree.

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D61/70849/2014

This research project has been submitted for examination with my approval as the University Supervisor.

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To our Father in Heaven, I say thank you for the opportunity and life.

God bless you all.

DEDICATION

I bestow this project to my family and especially my parents who have been very supportive during the entire period of my study. To Almighty God I cannot thank Him enough for the life and opportunities granted to me.

ABSTRACT

The study was entitled corrective maintenance practices and operational performance of manufacturing firms listed in the Nairobi securities exchange. The main objective of the study was to determine how the different corrective maintenance practices have an impact on the operational performance of the firms. It also sought to establish the extent of application of the various corrective maintenance practices by the firms and the remedial actions taken. The statement of the problem explains why the study was necessary. The study seeks to assist policy and decision makers to base their decisions on empirical evidence. A questionnaire was designed and administered in order to achieve the above objectives. Data collected was analyzed using MS excel and Statistical Package for Social Sciences (SPSS). The findings reveal that 23.1 % of the respondents use purely corrective maintenance while the rest use either preventive maintenance or a combination of the two maintenance policies. The study also shows that most of the firms use planned corrective maintenance strategies and not unplanned. A relationship was also established between corrective maintenance practices and the various variables of operational performance. This was in agreement with the other studies carried out on maintenance and operational performance as shown in chapter two under literature review.

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CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

In manufacturing firms maintenance with its different undertakings of resource management and measurement have become important. This is because it plays an important role in helping organizations to reach their goals of productivity, profitability and competitiveness and making sure that equipment operates effectively and efficiently (Baglee &Knowles, 2010).The main aim of manufacturing firms in the competitive world is to win customer's loyalty. This is done by boosting customer satisfaction without sacrificing quality. Efficiency drives quality and customer satisfaction hence creating opportunities for new products. Maintenance is an important factor in the manufacturing sector competitiveness because of its cost implication and that an equipment failure may have a critical impact on capacity utilization of equipment, quality of product, equipment operator and the environment (Leger et al., 2004). If the equipment is not functioning properly the processes will result in high quantities of scrap, work in progress or outputs of low quality (Smith &Hawkins, 2004).

Due to globalization and increased competition most of manufacturing firms are forced to operate their machines or systems at 70-80% utilization rate causing equipment to deteriorate at a higher rate (Savsar 2006).Hence, manufacturing companies have more pressure while producing goods to comply with the needs of increased availability, quality, speed, variability and efficiency (Alsyouf,2004). To achieve this firms have to integrate maintenance with other activities in the company and ensure that the equipment

is always in an operational state to perform its envisioned purpose effectively (Ben –daya & Duffua, 1995). This was supported by a report by the United Nations Industrial Development Organization's report on maintenance that cited the main contributing factor to low capacity utilization of firm's equipment as downtimes from breakdowns causing stoppage. The report also noted that to stimulate industrial development, maintenance culture in developing countries must be improved(World Bank, 1995).In perfectly maintained systems only preventive maintenance is applied Campbell , (2001) however as Salonen & Deleryd (2011) puts it this is not always practical necessitating the need for both preventive and corrective maintenance . Preventive maintenance ensures that the equipment is in proper working condition as corrective maintenance handles breakdowns that cannot be prevented.

1.1.1Corrective Maintenance Practices

Corrective maintenance / reactive maintenance/operate to failure/ breakdown maintenance are remedial actions taken after a machine failure or after identification of a deficiency during preventive maintenance to return the equipment to its operational state (Al Turki, et al.; 2014). It is an impromptu maintenance task made of unpredictable needs that cannot be planned in advance as they are not expected to occur. Corrective maintenance action however requires to be acted on urgently by interrupting the operations through integration or substitution of previously planned work.

According to Drury (1999) depending on the product and profit model developed during the design phase of a product, corrective maintenance can be of benefit or detrimental. It has a negative impact because it is an indication that something is not working and therefore machine downtime. This type of maintenance should therefore be utilized on non-critical areas where consequences of failure are low and does not influence the overall functioning of the equipment hence posing no risk for the operator Niu et al. (2010). Maintenance programmes in most cases consist of a mix of corrective, preventive and predictive maintenance practices. Vincent (2013), indicate that 50% of maintenance management activities are balanced between preventive and predictive maintenance activities. The stages in corrective maintenance include occurrence of a fault in the system, diagnosis of the cause of failure, replacement of the damaged part and finally a technician verifies that the fixed item is working by testing the system. Corrective maintenance can either be planned or unplanned .In this research we will review maintenance according to different corrective maintenance actions which generally include repair, rebuild, salvage, servicing, and failure replacement and overhaul (Wang, 2008).

1.1.2 Operational Performance

Christopher A, (1997) refers to operational performance in firms as the measurable aspects of an organization process such as reliability, production cycle time and inventory turns. The success of any firm is not only measured by financial aspects but also by the operational effectiveness which is an indication of the organizations pursuit for excellence and desire to excel in the competitive industry. Firm's operational

performance is measured by its ability to meet the objectives of quality, productivity and service (Alberto & Javier 2002). Corbett & Van's developed a model that has three dimensions of operational performance as quality. cost, and time. According to Murthy (2005), the effectiveness of a maintenance practice can be considered in four dimensions namely cost, quality, dependability and reliability, as measures of operational performance. Further, Marquez et al., (2009) asserts that operational objectives and performance measures need to be consistent to the declared overall business strategy.

For firms to be efficient they must put all the available resources into the best use so as to maximize output. This will yield low cost outputs due to decline in waste and value creation for customers. Quality which implies conformance to specification is measured by the number of defects produced during a production process and the cost of quality however the trend is shifting toward customer satisfaction. Reliability is time based, measuring the utilization rate of machinery and hence the ability to fulfill customer requirements. On time deliveries may have an impact on customer satisfaction (Slack et al, 2001). The other time based dimension of measuring operational performance is speed of the production process, which measure the process time from production to delivery of product to customer. By improving on the measurable aspects of operational performance: cost, quality, speed and reliability firms are able to achieve growth and a higher level of customer satisfaction as was the case in Japanese Toyota company (Toyotaism) (Ahmed, A., 2003).

1.1.3 Manufacturing firms listed in the Nairobi Securities Exchange

Kenyan manufacturing sector has drastically developed after the introduction of structural adjustment programs (SAP) in 1980s which liberalized the economy and encouraged competition among firms locally, regionally and internationally. Manufacturing firms in Kenya fall under the umbrella of Kenya Association of Manufacturers (KAM) established in1959 as a private sector body (Warima, 2014). Kenya's exchange market is grouped into eleven sectors. Namely banking, automobile and accessories, telecommunication and technology, agricultural, manufacturing and allied, growth enterprise market segment, commercial and services, energy and petroleum, construction and allied, insurance and investment, (www.nse.co.ke, 2014).

Most manufacturing firms use old equipment's/systems and maintain paper based documentation hence have difficulties in monitoring performance. The suppliers of equipment cannot also afford to upgrade the equipment into digital set-up forcing manufacturers who cannot manage to invest in new assets to invest in maintenance (Moore, 2003).According to Chellakumar (2012)operational performance is achieved through valuable outcomes such as customer satisfaction and higher returns. Machine downtimes in the manufacturing firms are one of the issues that hinder achievement of this objective. The production capacity determines the production rate. Therefore if maintenance is carried out effectively the production rate will consistently be good. Production time on the other hand depends on time taken on repairs and waiting times which also affects the quality of the product depending on the number of stops during the production process. This is besides the level of skills of the operator and the quality of

raw materials put into the process. Thus it can be concluded that availability of product is dependent on maintenance strategy indirectly or directly.

The research was thereby motivated by the present status of manufacturing sector in Kenya which requires that firms observe efficiency as a means of achieving economic improvement as required by NSE. It is also aimed at providing a policy perspective in the planning of corrective maintenance activities and assessment of its impact on the various operational performance measures.

1.2Research Problem

Maintenance has a critical role in any organization, and as such contributes to the competitiveness of the organization. Irregularities in equipment's cause's inconsistency in product features resulting in faulty products that do not meet quality specifications.. Effective corrective maintenance is vital for the achievement of organization goals as meager maintenance leads to high production cost, poor product quality; low employment of equipment and deferred schedules (Djerdjouri, 2005).This subsequently leads to production failure in the market and could lead the collapse of an organization.

Kenya's manufacturing sector which serves both the local market and exports to East Africa region contributed 9.2% of the country's gross domestic product as of 2012 (KIPPRA,2013). Firms listed on the Nairobi Securities Exchange (NSE) have encountered challenges (Capital Markets Authority, 2012a) in regard to their performance contrary to the expectations of the stakeholders who span across

shareholders, employees, consumers, and government among others. These firms are expected to increase their sales growth rates, expand their market share, increase productivity and profitability, which have not been realized by some of the firms. In support of the sector, the government put in place strategies to ensure a healthy existence of firms and progressive growth of the country as part of its development plans in vision 2030. These strategies include increased power supply, treaties with common markets East and South, manufacturing under bond among others.

Previous studies have reported that, maintenance cost account for between 15% - 70% of the total cost of production (Bevilaqua and Bragila, 2000). In addition maintenance related cost accounts for 25% of the operating cost in manufacturing firms(Simoes et al., 2011). It is further reported that about 30% of maintenance cost are due to failures in preventive maintenance ,poor planning and overtime (Salonen & Deleryd, 2011).With maintenance cost accounting for such a considerable portion of production cost, it is essential that the strategic management and development of maintenance be considered (Baglee & Knowles, 2010).

Literature suggests that performance measurement became a major part of operational performance since 1990s (Kumar, U., Galar, A., Stenstrom, C., Breges, L 2014).Several studies have been carried out on maintenance practices and equipment operational performance. A study bySwanson (2001) linking maintenance strategies to operational performance and Ngatia (2013)maintenance practices and power plants operational performance in Kenya. In a study by Warima (2014) it was found that large

manufacturing firms in Kenya use a combination of both corrective and preventive maintenance strategies with corrective maintenance strategy as the most prominent within the firms. However in a related study done by Tahboub (2011) in Jordan assessing the maintenance practices their industries, it was established that 44.8 % of the studied industries apply both preventive and corrective maintenance systems and 26 % of the industries apply only corrective maintenance. This shows that corrective maintenance still play an important role in maintenance strategies.

However, according to Adolfsson (2011) corrective maintenance as a field of study has not received significant academic interest as most of the researchers found focused on preventive or overall maintenance. It is against this, that this research finds the subject matter, corrective maintenance practices and operational performance as a practical problem worthy of investigation. Understanding this is important for the Operation Manager's decisions on repair speed and the maintenance policies to adopt. The research will be guided by the following questions: what corrective maintenance strategies have been adopted by manufacturing firms listed at the Nairobi Securities Exchange and is there a relationship between the corrective maintenance practices adopted and operational performance of manufacturing firms listed at the NSE?

1.3 Research objectives

The objectives of this research are

i. To determine the corrective maintenance practices commonly used by public large scale manufacturing firms in Kenya; and

ii. To establish the relationship between the corrective maintenance practices and operational performance of public large scale manufacturing firms in Kenya.

1.4 Value of the Study

This study will add literature in the field of corrective maintenance on operational performance.

The findings of the study will enable those charged with maintenance to make a decision on how much resource to invest on corrective maintenance as it has a critical role in maintenance policy. It will also assist those charged with maintenance of manufacturing systems to understand the factors influencing the successful implementation of corrective maintenance and whether corrective maintenance has a significant influence on the overall performance of the firm.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This section summarizes the information and results from other researchers who have carried out their research in a similar field of corrective maintenance strategies, operational performance and relationship between the two.

2.2 Corrective Maintenance Practices

Corrective maintenance is defined as actions carried out to bring back machinery which has ceased to meet suitable condition for working(Gopalakrishnan &Banerji, 2004).To Moayed (2009) it is one that occurs after the identification and diagnosis of a problem. It is maintenance identified by a condition monitoring system or due to breakdown. Corrective maintenance, as a subset of comprehensive preventive maintenance focuses on planned activities that maintain all parts of machinery and systems in best possible working form. The major aim of corrective maintenance is that repairs are carried out properly and completely on all emerging problems on a need basis. Also that the repairs are carried out by well-trained craftsmen and confirmed before the machine is returned to operation (Mobley, 2008c).

The major weakness of corrective maintenance is that there is unscheduled machine downtime and maintenance cannot be preplanned. If a machine part fails and the spare parts are not maintained by the firm or are not readily available delays ensue between the ordering and delivery of the spare parts (Chalifoux &Baired, 1999). If the firm had previously made commitments to manufacture and deliver the product at that particular

period a premium must be paid. Reduction in corrective maintenance time i.e. machine downtime is therefore important to improve maintenance effectiveness**.** Corrective maintenance ca be categorized into two: planned or unplanned (Marquez, 2007). In which case planned maintenance is as a result of shutdown maintenance plan, while the unplanned corrective maintenance is caused by breakdowns due to deficiency in the maintenance plan (reactive maintenance) or breakdowns not stopped by preventive maintenance.

2.2.1 Immediate/Unplanned Corrective Maintenance Practices.

This is maintenance carried out immediately with no postponement after an error has been discovered to avoid undesirable consequences. Usually, it is not in the maintenance plan and therefore very unpredictable that it cannot be planned in advance on a need basis at a particular time (Al-Turki et al., 2014). It's prompted by machine breakdown. The immediate maintenance practice can either be break down maintenance system or opportunistic maintenance system.

Run to failure maintenance: also known as breakdown maintenance is described by Al-Turki et al. (2014)as a practice where systems are maintained only after failure mostly of a critical nature.

Equipment is allowed to run till it fails. The action taken to restore the equipment into use can be servicing, repairing, replacement or overhaul. For manufacturing firms to adopt this practice they must ensure that they put certain provisions. This includes having a spare or support equipment that can be quickly brought into service upon failure of the

machine in use, having stock of spare parts and inventories of stock and work in progress that can be used as needed thereby avoiding lead times, having operators who are able to detect fault and deal with emergency failures and finally have maintenance staff who are well trained and readily available to carry out maintenance as and when need arises.

Opportunistic maintenance: is the methodical technique of collecting data about a system, investigating it, preplanning its maintenance activities, and making known a proposed set of maintenance activities and acting on them when a repair opportunity arises (Cui & Li 2006). This type of maintenance takes advantage of system shut down or system break down period to carry out maintenance that would have been performed in the immediate future thus reduces the time of system downtime. (Samhouri (2009) gives two reasons for using this strategy which are to broaden machinery lifespan or to increase the mean time to the next failure and to utilize the already dedicated time , efforts and resources in the maintenance of other parts of the equipment so as to reduce cost.

2.2.2 Deferred /Planned Corrective Maintenance Practices.

Planned maintenance is maintenance that is defined, documented, and done before equipment fails. In this type of maintenance practice a fault that has been detected in a part is delayed according to given maintenance rules so that production can continue without interruption. The key objective is to identify fault on time and correct it before breakdown occurs. This requires that firms put in place systems to monitor the machinery, plan for the corrective action within sufficient lead time without allowing the

machine to fail. This type of maintenance is appliedon non-vital areas where there are no immediate safety risks and potential failure can be identified on time, Niu et al., 2010.

Shutdown corrective maintenance: According to Al-Turki et al. (2014) manufacturing firms may adopt different maintenance systems for their individual systems. Shutdown maintenance is maintenance that is carried out when the entire production system is in total stoppage. It is a planned maintenance strategy that is carried out at least once in a year by manufacturing firms. It involves an overhaul of the entire manufacturing system therefore the procedures laid out for such maintenance should be followed strictly. For semi continuous manufacturing systems shutdowns are much easier due to their flexibility which allows application of both planned and unplanned maintenance.

Based on CRC Press LLC 2002 corrective maintenance action whether immediate of deferred can be done using various methods. These include servicing actions like inspection, oiling of parts and adjustments in order to minimize wear and tear and to prevent breakdown. Secondly, repairs which are done on a need basis apart from regular servicing, and in most cases are passive response. Thirdly, replacement which involves substituting parts which have reached the end of their economic useful life with new ones or with salvaged parts from other machinery. And finally, upgrading which includes carrying out improvements or rebuilding part of the machine or the entire machine in order to increase its performance standards.

2.3 Operational Performance

Mulwa (2000) notes that, for a firm to succeed, it must adopt efficient and effective production processes monitor and continuously improve those processes to sustain their long term survival. Therefore the production costs of an organization must be minimized while at the same time increasing its productivity, capacity, reliability and availability (Al-Turki 2011)**.**Gupta and Marquez (2005), asserts that, for an organization to be operationally successful, it must increase its productivity and minimize its costs. Wilson (2002) identified the business processes which should be used for optimizing operational performance. These are: minimizing maintenance costs, maximizing profitability of production by adopting optimal maintenance practices/concepts to reduce maintenance costs, maximizing equipment utilization, maximizing performance effectiveness and maximizing safety at the work place at an economical cost. Further, Daya etal, (2000) also identified machine availability as a measure of a Firm's operational success. Eti, Ogaji and Probert,(2006).Marseguerra et al., (2002) also noted that reliability as a measure of optimized maintenance management should determine the level of maintenance required. Management uses forecasted machine capacity in planning how to achieve cost, quality and delivery schedules therefore a suitable safety and maintenance strategy is mandatory to achieve the optimal production quantities (Daya et al., 2009).

Performance measurement helps to recognize the difference between the current performance and the desired performance Al Weber (2005). The aim of any manufacturer is to meet customer needs which are normally based on product quality, on time deliveries and fair pricing. This then forms part of manufacturing performance

measurement but includes other factors such as safety and environmental integrity Al Weber (2005). Different manufacturers have unique ways of categorizing performance which they base of various indicators. However there are common measures used by the manufacturers to measure equipment performance. These include frequency of breakdowns, mean time to repair and to failure, availability and overall equipment performance. They also consider cost related measures Kumar et al., (2011). This research will adopt measures of maintenance used by (Campbell 1995). These are measures are equipment availability /reliability, cost performance (maintenance cost and labor) and process performance (actual output verses planned).

2.4 Corrective Maintenance and Operational Performance.

The success of a manufacturing firm is dependent on the quality, cost and safety of the output and its production process. This output requires that equipment's have a highly successful and competent maintenance plan that ensures equipment availability and high asset value Al-Turki et al., (2014). Maintenance helps to eliminate undesirable consequences of asset failure Al Weber (2015). He adds that deterioration on equipment occurs as soon as equipment is put to use due to normal use and other failures such as when equipment is overworked and operator errors. These results in increased downtime, quality problems and operators are exposed to accidents. All of these can negatively impact operations.

Eti(2007) states that a careful selection of an optimized maintenance strategy would increase the reliability and availability equipments while reducing the operational and maintenance cost. This requires that the equipment design ensures maintainability so as to support the maintenance practices. Khan and Darrab (2010) propose that maintenance strategies can be used to reduce maintenance cost, improve on quality of production and overall equipment effectiveness and enhance equipment reliability .A study by Ngatia (2013) on maintenance practices and operational performance in 25 state and publicly owned power plants in Kenya revealed that there is a link between the two. However, for the higher operational plant performance adequate spare stocks supply in the power plants was very critical. A similar study by Mwangi (2014) concludes that plant availability effect on operational performance was high. It recommends enhanced availability of plants so as to maintain higher operational performance.

Mwanaongoro & Imbambi (2014) assessed the relationship between plant and equipment maintenance strategies and the factory performance in sugar firms in Kenya. The researchers used survey research design. A sample of sixty respondents composed of ten respondents from Mumias, Chemelil, Muhoroni, Nzoia, South Nyanza and West Kenya Sugar Companies was used to provide information for analysis. The study concluded that robust plant and equipment maintenance strategies were vital for factory performance.

Though many studies did not consider corrective maintenance as the sole independent variable to operational performance some studies captured it in research. Ubuni & Nwakanma (2012) in their study on effectiveness of maintenance policies for cellular

system infrastructure project established that mixed strategy maintenance and breakdown maintenance policies are unproductive and unsuitable for GSM transmission facilities because these maintenance strategies allow high idle times during downtime. He attributed this to the fact that breakdowns may be severe, complex and overdue, thereby making on time and efficient maintenance unachievable. In addition there is a time lapse between when the machine fails and when repairs are complete .Having an effective corrective maintenance thereby means carrying out repairs quickly in the shortest time, carrying out the correct maintenance action to return the machine into operation and putting into place measures to ensure that there is no recurrence of failures in a long enough periods while utilizing the lowest amount of resources in carrying out the repairs.

2.6 Conceptual Framework

Carrying out corrective maintenance (planned or unplanned) in the most efficient and effective way remains one of the very few ways in which operational performance of a manufacturing firm can be improved. The independent variable is the corrective maintenance practice while the dependent variable is the factory performance (corrective maintenance result indicators). The intervening variables are organizational policies. The research seeks to establish the relationship between the independent and dependent variables which guided the study as summarized in the conceptual framework model, figure 2.4 below

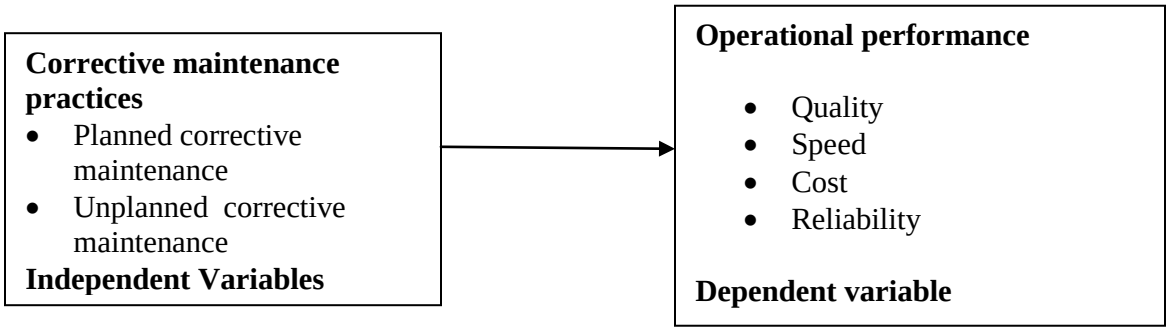

Fig.2.1Conceptual model

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter summarizes the techniques employed in carrying out the study. It describes the research design, target population, data collection process, and data analysis.

3.2 Research Design

The study was a survey where data was collected from the entire study population during the time of the study to analyze the association between corrective maintenance as the independent variable and operational performance as the dependent variable. According to Mugenda and Mugenda (2003), this type of study allows for data to be collected from the identified group with the intend of identifying the current condition given the specific variables. In this case, the corrective maintenance practices with respect to operational performance measurement variables. The design was used since it is the most suitable to facilitate collection of information necessary to achieve the research objectives. The data collected will be quantified analyzed and reported as a depiction of features in the study population.

3.3 Target Population

For the purpose of this study, large scale manufacturing companies listed in the Nairobi Securities Exchange were used as the population. A census was used. According to NSE list 2016 there are 21(twenty one) public large scale manufacturing companies operating in the country. NSE has classified the firms into the sectors of agricultural (6), manufacturing and allied (10) and construction allied (5). As shown in the appendix 1.

3.4 Data Collection

Data was collected by conducting interviews with production managers, or their representatives who have the role of managing the operations of the plant and maintain plant records. Secondary data on the maintenance cost and downtime of the equipment was used to measure the performance of the systems.

The data was collected through questionnaire which was structured to allow for uniformity of responses. The questionnaire entailed both closed and open ended questions that were designed to drive out precise responses in order to meet the objective of the study.

3.5 Data Analysis

Data was collected, sorted and coded using numerical numbers. Then, entered in the Statistical Package for Social Sciences (SPSS) software and analyzed. Measures of central tendency which include frequencies, standard deviation and mean was used to rank and interpret the data. For a 5 point scale, a mean of 3 and above indicated that the practice is popularly used by all the firms. The standard deviation was used to describe the variability of the scores. A lower value of standard deviation indicated consistency while a higher value indicated inconsistency.

Regression analysis was used to examine the relationship between the dependent and independent variable. The analysis was done in two steps. First, determination of corrective maintenance practices used manufacturing companies. Second, testing the

performance implications of the corrective maintenance practices and then the relationship between the two.

The following table summarizes how each of the operational performance indicators was measured.

No.		Measure	Indicators
1	Quality	Quality rate Q = processed amount − Defective amount X100 processed amount	Yield Customer rejects/return material
2.	Delivery	D = Planned time – downtime X 100 Planned time	Planned vs. emergency maintenance work orders. Machine downtime
3.	speed	Manufacturing time cycle	Process time
4.	Cost		Total maintenance cost
5.	Health and safety		Reported health , safety and environmental incidents.

CHAPTER FOUR: DATA ANALYSIS, FINDINGS INTERPRETAION AND DISCUSSION

4.1 Introduction

This chapter summarizes the information which was collected through a questionnaire. Data was analyzed using MS excel and SPSS. Mean and standard deviation was used to evaluate and interpret the data. For a 5 point scale, a mean of 3 and above will indicates that the practice is popularly used by all the firms.

4.2 Response per category of firm

The questionnaire targeted to receive data from a population of twenty one-(21) manufacturing firms listed in the NSE. Responses were received from thirteen (13) stations which represent 65% response rates A response rate of above 50 % is adequate for study and scrutiny .Mugenda & Mugenda (1999).

4.3 Plant maintenance strategy used by large manufacturing firms in Kenya

There are mainly two types of maintenance strategies used by firms. These corrective maintenance strategy that is carried out following detection of and normally and aimed at restoring normal operating condition and preventive maintenance strategy that is carried out at a planned intervals aimed at reducing the risks of failure. The respondents were requested to point out which maintenance philosophy they used. The research findings are as per table 1 below showing the frequency and percentages of application of the variables.

Table 1 Maintenance strategy adopted by the manufacturing firm listed in the NSE

	Maintenance strategy	N	Frequency	Percentage %
1	Corrective maintenance	13	3	23.1
2	Preventive maintenance	13	4	30.8
3	Preventive and reactive maintenance	13	6	46.1
	TOTAL	13	13	100

The results indicated that 23.1% of the firms use reactive maintenance strategy, 30.8 % of the firms use preventive maintenance strategy while 46.1% use both preventive and reactive maintenance strategy. This means that most of the firms use a combination of both reactive and preventive maintenance strategies. This finding is similar to that of Yusuf (2013).The research indicated that 24 % of the firms used reactive/corrective maintenance strategy ,17.6 % used preventive maintenance strategies while 58.8 % used a combination of both. This implies that most firms want to be in control of their maintenance and are aware of the risks of running their machines to failure.

4.4 Immediate corrective maintenance practices applied by large scale manufacturing firms listed in the NSE

4.4.1 Application of run to failure /break down maintenance practices by large scale manufacturing firms listed in the NSE

Run to failure maintenance is a corrective maintenance practice used by manufacturing firms whereby systems are maintained only after failure. The respondents were asked to indicate to what extent they applied the practices in relation to corrective maintenance

strategy. They responded to various practices under the variable on a five point likert scale.(5 being 'Always used', 4'mostly used', 3: 'Sometimes used', 2 'Rarely used' 1: 'Never used'. the research findings are a s in table 2 below showing the resultant mean and standard deviation of the variables.

Table 2 Run to failure corrective maintenance practices applied by manufacturing firms

	Maintenance practice.	**N**	**Mean**	**Std dev**
	Immediate / unplanned corrective maintenance practices			
	Breakdown maintenance			
1	The firm uses well trained craftsmen to carry out repairs on the machinery.	13	4.37	0.782
2	The firm carries out maintenance immediately when a fault has been detected	13	4.24	0.751
3	The firm carries out maintenance after breakdown of an equipment	13	4.22	0.743
4	The firm ensures that the repairs are verified before the machine is returned into operation	13	4.14	0.707
5	The firm uses run to failure maintenance plan while carrying out corrective maintenance	13	4.14	0.354
6	The firm carries out maintenance after identification and diagnosis of a problem.	13	4.00	0000
7	The firm uses large portions of monthly maintenance hours available on corrective/emergency maintenance	13	3.84	1.196
8	The firm carries out corrective maintenance on breakdowns not stopped by preventive maintenance.	13	3.59	0.497
9	The firm carries out inspection and repair to only what caused breakdown as per maintenance serviceability standards	13	3.153	1.214
	Overall mean		3.96	

To a great extent (mean ≥3.5) firms always used well trained craftsmen to carry out repairs on their equipment (4.37), the firm mostly carried out maintenance immediately when a fault has been detected(4.24), the firm carry out maintenance after breakdown of an equipment(4.22),the firm ensures that the repairs/maintenance are verified before the machines are returned into operation (4.14),the firms use run to failure maintenance while carrying out corrective maintenance (4.14),and the firms carried out maintenance after identification and diagnosis of a problem (4.00). The firms also sometimes use large portions of monthly maintenance hours available on corrective/emergency maintenance (3.84) and carried out corrective maintenance on breakdowns not stopped by preventive maintenance (3.59). To a moderate extent (mean≤3.5) firms sometimes carried out inspection and repair to only what caused breakdown as per maintenance serviceability standards. (3.15).

This means that large scale manufacturing firms listed in the NSE apply run to failure / breakdown corrective maintenance practice in a moderate extent with an overall mean of (3.96). Based on a survey carried out in the US and Australia in 2008, this strategy is commonly used because of manpower shortage and lack of a budget for better monitoring and control of equipment

4.4.2 Application of opportunistic maintenance practices by large scale manufacturing firms listed in the NSE

In opportunistic maintenance firms use unscheduled downtime to carry out preplanned maintenance. The respondents were asked to specify to what level they applied the following practices in relation to opportunistic maintenance. They responded to various practices under the variable on a five point likert scale. (5 being 'Always used', 4'mostly used', 3: 'Sometimes used', 2 'Rarely used' 1: 'Never used'. the research findings are as in table 3 below showing the resultant mean and standard deviation of the variables.

Table 3. Opportunistic corrective maintenance practices applied by manufacturing firms

Opportunistic maintenance	**N**	**Mean**	**Std dev**
The firms maintains a methodical technique of collecting data about a system, investigating it, preplanning its maintenance activities, and publishing a proposed set of maintenance activities and works on them when a restoration opportunity arises	13	3.461	1.12
The firm postpones maintenance tasks until an unscheduled repair opportunity	13	1.84	0.80
Overall mean		2.65	

To a great extent (mean $\geq$3.5) the firms sometimes applied opportunistic maintenance practices in the maintenance of their systems/equipment. The respondents indicated that sometimes they maintain a methodical technique of collecting, investigating and planning in advance tasks of maintenance and acts on them when there is out of the blue breakdown or restoration opportunity (3.461). However, to a low extent (mean $\leq$2.5) the firms indicated that they really postpone maintenance activities until an unscheduled repair opportunity.

With an overall mean of (2.65), this means that large scale manufacturing firms rarely apply opportunistic maintenance practices in the maintenance of their equipment's. This implies that maintenance is carried out immediately when fault has been diagnosed. This may be attributed to the health and safety concerns of running a machine that needs repair and also that the machine gets into a worse condition if used when spoilt. According to S. Samhouri et al (2009) it is important for firms to set up proper maintenance capacities to control wear and tear in order to successfully apply the opportunistic maintenance strategy and minimize the impact on the operation of the equipment be it cost-effectiveness or safety.

4.4.3Planned corrective maintenance practices applied by large scale manufacturing firms listed in the NSE

This is a corrective maintenance practice that is defined documented and done before equipment fails. The respondents were asked to indicate to what extent they applied the following planned corrective maintenance practices in their firms. They responded to

various practices under the variable on a five point likert scale. (5 being 'Always used', 4'mostly used', 3: 'Sometimes used', 2 'Rarely used' 1: 'Never used'. The research findings are as in table 4 below showing the resultant mean and standard deviation of the variables.

Table 4.Planned corrective maintenance practices applied by manufacturing firms

Planned corrective maintenance practices	N	Mean	Std deviation
The firm monitors equipment failure with a view of taking corrective action before failure occurs	13	4.46	0.51
The firm does condition monitoring of the equipment	13	4.3	0.63
The firm carries out tasks that are planned to maintain plant and machinery in the best operating condition.	12	4.26	0.60
The firm carries out corrective maintenance while the production line is in total stoppage	13	3.92	1.12
The firm defines, documents and carries out corrective maintenance before equipment failure	13	3.69	0.63
Overall mean		4.126	

To a great extent (mean $\geq$ 3.5) firms applied planned corrective maintenance practices. The respondents indicated that they always monitor equipment failure with a view of taking corrective action before failure occurs (4.46) , they sometimes do condition monitoring of equipment (4.3), carry out tasks that are planned to maintain plant and machinery in the best operating condition (4.26),carry out corrective maintenance while the production line is in total stoppage (3.92) and defined ,documented and carried out corrective maintenance before failure of an equipment(3.69).

An overall mean of 4.123 indicates that the firms mostly apply planned corrective maintenance. The low standard deviation in most of the variables indicates that there was consistency in most of the responses. The most common used planned corrective maintenance practice is as ranked in the table above. Most of the practices were mostly used by the firm part from factor no 4 and 5. This may be attributed to the fact that it is dangerous to carry out maintenance while the machine is in use and that most of the firms are process industries where an output from one process forms an input in another process.

4.4.4Mechanismsput in place by the large scale manufacturing firms to ensure that corrective maintenance is carried out effectively

These are the systems put in place by firms to ensure that corrective maintenance is carried out in an efficient and effective way. The respondents were asked to indicate to what extent they applied the following measures to ensure that corrective maintenance is carried out efficiently in their firms. They responded to various measures under the variable on a five point likert scale.(5 being ‘Always used’, 4’mostly used’, 3: ‘Sometimes used’, 2 ‘Rarely used’ 1: ‘Never used’. The research findings are as in table 5 below showing the resultant mean and standard deviation of the variables.

Table 5 Measures put in place to ensure that corrective maintenance is carried out efficiently

Mechanisms to ensure that the corrective maintenance is carried out efficiently	N	Mean	Std deviation
The firm has maintenance staffs that are readily available to diagnose and correct problems with equipment.	13	4.62	0.52
The firm uses well trained craftsmen to carry out repairs on the machinery.	13	4.61	0.50
The firm maintains buffer inventories of work in progress	13	4.38	0.65
The firm maintains spare part inventory that can be fitted as needed	13	3.07	0.76
The firm maintains a standby or backup equipment that can be quickly brought into service upon failure of another	13	1.30	0.48

To a great extent (mean $\geq$ 3.5) firm always have maintenance staffs that are readily available to diagnose and correct problems with equipment (4.62), use well trained craftsmen to carry out repairs on the machinery (4.61) and maintain buffer inventories of work in progress (4.38). In addition firms sometimes maintained spare part that can be fitted as needed (3.07). To a low extent (mean $\leq$ 2.5) firms maintained a standby or backup equipment that could be quickly brought into service upon failure of another.

As per the ranks indicated in table 5, most firms ensure that corrective maintenance is carried out in an efficient manner by having maintenance staff that is always available and well trained to diagnose and repair problems with equipment. The findings are similar to those of A Shagluf;PLongstaff &; S. Fletcher (2014) who concluded that higher machine uptime and overall equipment effectiveness can only be achieved if firms have machine operators who are effective.

4.4.5Corrective action taken by large scale manufacturing firms during corrective maintenance.

These are actions taken to ensure that the machinery is taken back to operational state. The respondents were asked to indicate to what extent they applied the following corrective maintenance actions in their firms. They responded to the various actions under the variable on a five point likert scale. (5 being 'Always used', 4'mostly used', 3: 'Sometimes used', 2 'Rarely used' 1: 'Never used'. The research findings are as in table 6 below showing the resultant mean and standard deviation of the variables.

Table 6 Corrective maintenance actions applied by manufacturing firms

Corrective action taken	N	Mean	Std deviation
The firm carries servicing of equipment which includes inspection cleansing, oiling and adjustments.	13	4.53	0.51
The firm carries out repairs on a need basis apart from the regular service and in most cases they are passive response	13	4.30	0.85
The firm carries out replacement of elements or parts of an equipment when they reach the end of their economic expected life	13	3.76	1.09
The firm carries out improvements and refurbishment to upgrade part or portion of the equipment to higher standard after failure	13	3.23	.83
The firm ,during maintenance disassembles all components, examine worn out parts and replace them as per original specification and reassembly done	13	2.46	0.52
The firm uses salvaged materials from other equipment to carry out repairs of broken parts.	13	2.30	0.63

To a great extent (mean$\geq$3.5) firms mostly carried out servicing of equipment which includes inspection cleansing, oiling and adjustments (4.53) and carried out repairs on a need basis apart from the regular service which in most cases are passive responses

(4.30). In addition the firms sometimes carry out replacement of elements or parts of equipment when they reach the end of their economic expected life (3.76) and carried out improvements and refurbishment to upgrade parts or portion of the equipment to higher standard after failure (3.23). However, to a low extent (mean≤2.5) firms rarely used salvaged materials from other equipment's to carry out repairs of broken parts (2.30).They also rarely during maintenance disassembled all components, examine worn out parts, replace them as per original specification and reassemble them during maintenance (2.46).

The most applied corrective maintenance action is servicing which includes inspection, cleansing, oiling and adjustments. This finding supports the thoughts of Niu et al (2010) that corrective maintenance should only be employed in non-vital areas where cost of capital is small, no safety risk are immediate and the consequences of failure do not affect the complete system purpose.

4.4.6 Factor analysis.

Factor analysis was performed. Factor analysis helps in value variable reduction to pick the variable that well explains other variables adequately. The above process was performed on both the independent and dependent variable in order to obtain a sensible model.

Table 7 Factor analysis table

Component Matrix			
	Component		
	1	2	3
The firm carries out maintenance after breakdown of an equipment	.888	.338	
The firm uses well trained craftsmen to carry out repairs on the machinery	-.502	-.468	-.609
The firm ensures that the repairs are verified before the machine is returned into operation		-.490	.824
The firm uses run to failure maintenance plan while carrying out corrective maintenance	.787	.322	
The firm carries out maintenance immediately when a fault has been detected	-.738	-.589	
The firm uses large proportions of monthly maintenance hours available on reactive /emergency maintenance.	.951		
The firm carries out inspection and repair to only what caused breakdown as per maintenance serviceability standards	.848		-.409
The firm maintains a standby or backup equipment that can be quickly brought into service upon failure of another	.863		
The firm maintains spare parts inventory that can be fitted as needed	-.773	.547	
The firm maintains buffer inventories of work in progress	-.599	.533	.584
The firm has maintenance staffs that are readily available to diagnose and correct problems with equipment.	-.698	.615	
Extraction Method: Principal Component Analysis.			

Total Variance Explained

Component	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.017	54.701	54.701	4.445	40.409	40.409
2	2.114	19.219	73.921	3.582	32.563	72.972
3	1.847	16.789	90.710	1.951	17.738	90.710

The PCA technique (Principal Component Analysis) where we pick the highest variance to represent our variable was used. It is argued that the value with the highest variance explains other variables adequately hence it is sufficient. The tables represent the correlation matrices used to identify the variances. When values are extracted the value with the highest variance is picked.

Kaiser Meyer Olkin (KMO) was used to test sampling adequacy. It's measured between 0-1 and a value >0.5 is said to be adequate. Our sample is adequate as indicated in the table 4.5.1 below by a value of 0.628. With a p value of $0.000 < 0.005$ the sample is said to be significantly different from zero and hence sufficient enough to test the relationship between the dependent and independent variable.

Sampling adequacy

Kaiser-Meyer-Olkin Measure of Sampling		.628
Adequacy	Approxima.Chi-square	167.60
Bartlett's Test of SphericityDf		10
	Sig	.000

4.5 Firms operational data

Manufacturing firms were asked to provide operational data of their firms. The response was as per the table below.

Table 8 Firms operational data

Firm	Utilization rate	No. of machine failures	% Goods that are manufactured correctly for the first time.	Total maintenance Cost Kshs '000'	Work in progress as a percentage of planned production.	Reportable incidents on employees
1	72	1	80	1,006,000	69	2
2	63	1	84	102,189	71	2
3	72	1	83	38,371	72	2
4	67	1	83	434, 293	73	2
5	75	2	83	1,008,460	71	3
6	78	2	80	186,233	71	2
7	75	2	82	190,143	69	2
8	76	1	84	950,699	68	2
9	76	2	82	435,834	72	2
10	75	1	81	682,457	71	3
11	77	2	83	359,434	75	3
12	68	1	85	864,031	74	2
13	77	1	80	804,570	69	3

4.6 Relationship between corrective maintenance practices and operational performance of manufacturing firms listed in the NSE

Multiple Regressions was performed to determine the relationship between corrective maintenance practices and operational performance. Each dependent variable (Reliability, cost, Quality, speed and Health and safety) was used to regress on the independent variable unplanned and planned maintenance as shown below using the following model.

$Y = Bo + a+b$

Where Y- is the dependent variable

Bo -is the constant

a- effect of unplanned corrective maintenance on dependent variable Y

b- effect of planned corrective maintenance on dependent variable Y

4.6.1 Dependent variable reliability

A regression model was run to establish the relationship between corrective maintenance practices and reliability as a measure of operational performance. Capacity utilization rate was used to measure reliability .The results are a s shown below

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	73.049E-017	.138		.000	1.000
	Unplanned-independent variable	.182	.140	.182	1.299	.200
	planned-independent variable	.159	.140	.159	1.138	.261

$Y=Bo + a+b$

where

Where Y- is the dependent variable – Reliability

Bo -is the constant – level of reliability obtained with no corrective maintenance

a- Effect of unplanned corrective maintenance on dependent variable Y

b- Effect of planned corrective maintenance on dependent variable Y

Y= 73.049 +0.182 a +0.159b

NOTE: The value of the constant is neglible or is zero

Holding all other factors constant, for every unit increase of unplanned corrective maintenance reliability increases by 0.182units and for every unit increase in planned corrective maintenance reliability increases by 0.159 units. The significant values show that the coefficients of the independent variable are not significantly different from zero as they are greater than 0.05.). From the regression results it is evident that the hypothesis that there is a relationship between corrective maintenance and operational performance (reliability) is not supported.

4.6.2. Dependent Variable: Cost

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	511015.118	39286.947		13.007	.000
Unplanned-independent variable	55215.632	39733.107	.191	1.390	.171
planned-independent variable	-72437.441	39733.107	-.251	-1.823	.075

Y =511015.19 +55215.63a -72437.44b.

Where Y = Bo + a+b

Where Y- is the dependent variable cost

Bo -is the constant – the cost that will be incurred when there is no corrective maintenance

a- effect of unplanned corrective maintenance on dependent variable Y

b- Effect of planned corrective maintenance on dependent variable Y

For every one unit increase in unplanned corrective maintenance, cost increases by Kshs 55,215.62. While for every unit increase in planned maintenance, cost decreases by ksh 72,437.41. The cost of maintenance is Kshs 511,015.11 when no investment is made in both planned and unplanned corrective maintenance. This can be accredited to the fact that cost can be saved when corrective maintenance is carried out before failure of equipment to avoid costs such as down time cost and failure to deliver customer demands hence the negative coefficient of planned maintenance. The coefficient for the constant value is significantly different from zero while that of the independent variables are not as they are $\geq$0.05.From the regression results it is evident that the hypothesis that there is a relationship between corrective maintenance and operational performance (cost) is not supported.

4.6.3 Dependent variable: Quality

A regression analysis was carried out to determine the relationship between corrective maintenance and quality as the dependent variable. The results are a shown below

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	82.137	.262		314.040	.000
	Unplanned-independent variable	.163	.265	-.087	-.617	.540
	planned-independent variable	.315	.265	-.169	-1.192	.239

Y =82.137 +0.163a+0.315bY

Where Y = Bo + a+b

Where Y- is the dependent variable quality

Bo -is the constant – level of quality that will be achieved when there is no corrective maintenance

a- effect of unplanned corrective maintenance on dependent variable Y

b- Effect of planned corrective maintenance on dependent variable Y

.From the analysis it is shown that 82.13 % or quality was attributed to factors other than corrective maintenance. In addition, for every unit increase in unplanned corrective maintenance quality of production increases by 0.163 % and for a unit increase in planned corrective maintenance quality increases by 0.315%. The beta was insignificant at for unplanned corrective maintenance (beta = -.0.87, t=-0.617 p=0.54>0.05) and for planned maintenance (beta =-0.169, t = -1.192, p=0.239> 0.05). From the regression results it is evident that the hypothesis that there is a relationship between corrective maintenance and operational performance (quality) is not supported.

Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.021	.123		.170	.866
Unplanned-independent variable	.142	.125	.141	1.135	.262
planned-independent variable	.515	.122	.521	4.207	.000

4.6.4. Dependent Variable: speed

A regression analysis was carried out to determine the relationship between corrective maintenance and speed as the dependent variable. The results are a shown below

Y=0.021+0.142a+0.515b

Y = Bo + a+b

Where Y- is the dependent variable speed

Bo -is the constant – level of speed that will be achieved when there is no corrective maintenance

a- effect of unplanned corrective maintenance on dependent variable Y

b- Effect of planned corrective maintenance on dependent variable Y

For every one unit increase in unplanned corrective maintenance speed increases by 0.142 and an increase in planned corrective maintenance causes speed to increase by

0.515. It is also evident that there is a significant relationship between speed and planned maintenance p=.000<0.5. This may be attributed to the fact that with planned corrective maintenance the production plan has already been considered and hence there are no delivery delays caused by break down maintenance. For the other variable, Bo and unplanned corrective maintenance the relationship cannot be supported.

4.6.5. Dependent Variable: health and safety

A regression analysis was performed using corrective maintenance as the in depended variable and health and safety as the dependent variable measuring operational performance. The results are as per the table below.

Coefficients[,]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.136E-016	.143		.000	1.000
	Unplanned-independent variable	-.020	.144	-.020	-.141	.889
	planned-independent variable	.062	.144	.062	.431	.668

y= 2.136 -0.020a+0.062b

Y = Bo + a+b

Where Y- is the dependent variable, health and safety issues.

Bo -is the constant – number of health and safety incidents when there is no corrective maintenance

a- effect of unplanned corrective maintenance on dependent variable Y

b- Effect of planned corrective maintenance on dependent variable Y

NOTE: The value of the constant is very small and is rounded off to zero

For every one unit increase in unplanned corrective maintenance safety decreases by 0.020 units and for every unit increase in planned corrective maintenance health and safety increases by 0.062 units holding all other factors constant. The beta was insignificant at (beta = -.0.20, t=-1.41 p=0.889>0.05) and for planned maintenance (beta =0.62, t =0.431, p=.668> 0.05). From the regression results it is evident that the hypothesis that there is a relationship between corrective maintenance and operational performance (number of health and safety incidents) is not supported. This means that the health and safety incidents may be attributed to other factors such as employee's negligence or power failures and not failures in the corrective maintenance plan.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents summary of findings in chapter four, the conclusions and recommendations made there from.

5.2 Summary of the findings.

From the findings it is established that from the 13 respondents only 23.1% use reactive/corrective maintenance purely while 30.8% use preventive maintenance and 46.1 uses a combination of both. This is mostly attributed to the fact that preventive maintenance practices cannot fully eliminate maintenances due to breakdown.

It can also be observed that most of the manufacturing companies do planned corrective maintenance as opposed to unplanned corrective maintenance. This is described by the two mean of means with planned corrective maintenance having a mean of 4.126 as compared to unplanned maintenance which has a mean of 3.96. This can be explained by the fact that firms do monitor their equipment in order to avoid breakdowns which does not only cost time and money but may be a threat to the safety of the employees. In addition most of the firms have planned shout downs during which maintenance is carried out at least once in a financial year.

It was found that most of the firms had maintenance staff that was readily available to diagnose and correct problems with equipment. These staff was also well trained to carry out repairs on machinery. The least employed mechanism to ensure that operations went on smoothly after break down was having standby machinery. This may be attributed to the fact that most of the machinery used in the manufacturing firms requires huge capital investments and it is therefore not viable to maintain standby equipment. It may also be due to the fact that it will maybe require more time to set up the standby machinery that to repair the broken down equipment. Other methods used but in low proportions to ensure that corrective maintenance is carried out efficiently included maintaining buffer inventories of work in progress and having spare parts inventories respectively.

In most instances the corrective action taken included inspection, cleansing, oiling and adjustment. Repairs were carried out on a need basis and were passive in response. The firms did not, disassembles all components, examine worn out parts and replace them as per original specification during maintenance.

However, a relationship between corrective maintenance and operational performance was found to exist in the manufacturing firms listed in the NSE. From the regression analysis carried out on each of the dependent variables. In some cases the relationship was strong while in others weak as stated in chapter 4. However, the relationships could not be adequately supported.

5.3 Conclusion

From the analysis of findings we conclude that only 23.1% of operational performance can be attributed to corrective maintenance practices applied by the listed manufacturing firms in Kenya. In addition most of the firms prefer to use planned corrective maintenance strategies as opposed to unplanned corrective maintenance strategies. Lastly, it was established that there exists a relationship between the corrective maintenance practices and operational performance. This is shown by the increase in operational variables of quality, speed, reliability when both planned and unplanned corrective maintenance is used. However cost seemed to reduce when planned maintenance was used and increase when unplanned corrective maintenance was used.For the variable on health and safety, it was seen that the safety of the work environment reduced when unplanned maintenance was used and increased when planned maintenance was applied.

5.4 Recommendations

Though less than 25% of the operational performance of firms can be attributed to corrective maintenance, managers need to put in place strategies that will ensure that corrective maintenance is done in the most functional way as and when the need arises. The decision to adopt a particular corrective maintenance policy should be based on resource constraints and the cost considerations. This is because as seen from the research maintenance has a big cost implication as shown on the coefficients in the cost regression model.

Since this research focused on the timing of the corrective maintenance practices , in future researchers should consider other corrective maintenance techniques such as redundant components, alternate routings, increased maintenance crew size, and modular design for equipment and their impact on performance . More research also need to be done to establish whether the findings of this research were true. This is because in most of the regression analysis carried out it was established that there was no significant relationship between corrective maintenance practices and each operational performance.

5.5 Limitations of the study

The study required collection of data which was considered confidential by most of the plant managers. Time was also required by some of the available respondents to obtain permission to provide the necessary information. In some instances we were not able to receive all the required information on operational performance. Editing was done on such data before it was used in such data. In addition some of the manufacturing firms studied were located far away and we were not able to collect data from them.

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APPENDICES

Appendix 1: Public Large Scale Manufacturing Firms Listed the NSE by Sector

a) Agriculture	b) Manufacturing and Allied	c) Construction and allied
Rea Vipingo Ltd	BOC Kenya	EA Portland Cement
Eaagads	Carbacid Investments	Bamburi Cement
Kapchorua tea company	East Africa Breweries	East Africa Cables
Sasini Tea and Coffee Ltd	Eveready East Africa	Athi River Mining Ltd
The limuru tea company	Flame tree group holdings	Crown paints Kenya
Kakuzi Ltd	Kenya orchards	
	Mumias Sugar Company	
	Unga Group	
	British American Tobacco Kenya	
	A Baumann & co.	

APPENDIX 2 QUESTIONNAIRE

SECTION 1 a MAINTENANCE STRATEGIES APPLIED BY FIRM

Please indicate which of the following maintenance strategies are used in your organization.

	Maintenance practice	**Yes**	**No**
1	Reactive maintenance		
2	Preventive maintenance		
3	Preventive and reactive maintenance		

SECTION 1b: CORRECTIVE MAINTENANCE PRACTICES APPLIED BY FIRMS

In a Likert scale of out of 5: 5 being 'Always used', 4'mostly used', 3: 'Sometimes used', 2 'Rarely used' 1: 'Never used'. Please indicate extent to which the following corrective maintenance practices are used in your organization.

	Maintenance practice.	**1**	**2**	**3**	**4**	**5**
1.	The firm carries out maintenance after identification and diagnosis of a problem.					
2.	The firm carries out maintenance after breakdown of an equipment					
3.	The firm does condition monitoring of the equipment					
4.	The firm carries out planned tasks that will maintain all critical plant and machinery in optimum operating					

	condition					
5	The firm uses well trained craftsmen to carry out repairs on the machinery.					
6	The firm ensures that the repairs are verified before the machine is returned into operation					
7	The firm uses run to failure maintenance plan while carrying out corrective maintenance					
8	The firm carries out corrective maintenance on breakdowns not stopped by preventive maintenance.					
9	The firm uses large proportions of monthly maintenance hours available on corrective/emergency maintenance.					
10	The firm carries out maintenance immediately when a fault has been detected					
11	The firm carries out inspection and repair to only what caused breakdown as per maintenance serviceability standards					

12	The firm maintains a standby or backup equipment that can be quickly brought into service upon failure of another					
13	The firm maintains inventory of spare parts that can be installed as needed					
14	The firm maintains buffer inventories of work in progress					
15	The firm has maintenance staffs that are readily available to diagnose and correct problems with equipment.					
16	The firm maintains a methodical technique of collecting data about a system, investigating it, preplanning its maintenance activities, and making known a proposed set of maintenance activities and acting on them when a repair opportunity arises					
17	The firm monitors equipment failure with a view of taking corrective action before failure occurs					

18	The firm postpones maintenance tasks until an unscheduled repair opportunity					
19	The firm monitors equipment failure with a view of taking corrective action before failure occurs					
20	The firm defines, documents and carries out corrective maintenance before equipment failure					
21	The firm carries out maintenances based on given maintenance rules					
22	The firm carries out corrective maintenance while the production line is in total stoppage					
23	The firm carries serving of equipment which includes inspection cleansing, oiling and adjustments.					
24	The firm carries out repairs on a need basis apart from the regular service and in most cases they are passive response					
25	The firm carries out replacement of elements or parts of an equipment when they reach the end of their economic expected life					

26	The firm uses salvaged materials from other equipment to carry out repairs of broken parts.					
27	The firm ,during maintenance disassembles all components, examine worn out parts and replace them as per original specification and reassembly done					
28	The firm carries out improvements and refurbishment to upgrade part or portion of the equipment to higher standard after failure					
29	The firm has put in place mechanisms to align its maintenance with its operations.					

SECTION 2: OPERATIONAL PERFORMANCE DATA COLLECTION FORM

Please provide the operating data of equipments at your plants.

Operational performance indicator	**Metrics**	**Firm performance Last financial year**
Equipment/process performance	Capacity utilization rate %	
	Mean time to repair (hours)	
	Mean time before failure (hours)	
	Number of machine failures reported in the year	
	Actual production as a percentage of work orders/planned production.	
Output product quality	% of goods that are manufactured correctly at the first time.	
	Goods returned by customers as a percentage of sales.	
Cost	Total maintenance cost	
	Actual maintenance cost vs. budgeted maintenance cost	
Health and safety	Number or reportable health and safety incidents on employees	