OPERATIONS MANAGEMENT PLANNING AND PREVENTIVE MAINTENANCE IN GRAIN MILLING COMPANIES IN NAKURU COUNTY, KENYA

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DECLARATION

This research Project is my original work and has not been submitted for examination to any other University or College for the award of degree, diploma or certificate.

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This research Project has been submitted for examination with my approval as the University supervisor.

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DEFINITION OF OPERATIONAL TERMS

Efficiency Is the relationship of what is actually produced or performed with what can be achieved with the same consumption of resources in a system. In this study efficiency of preventive maintenance will be considered and will be determined based on the percentage machine availability.

Manpower Planning Manpower Planning which is also called as Human Resource Planning consists of putting right number of people, right kind of people at the right place, right time, doing the right things for which they are suited for the achievement of goals of the organization. In this study, manpower planning is looked in from the lens of maintenance staffing.

Plant Layout Refers to the layout of materials, machines, equipment, and other manufacturing supports and facilities to create the most effective plant layout.

Preventive Maintenance Is the regular and systematic application of engineering knowledge and maintenance attention to equipment and facilities to ensure their proper functionality and to reduce their rate of deterioration. This form of maintenance is primarily conducted in order to prevent failure before it occurs.

Production Planning - production planning is part of a hierarchical planning, capacity/resource allocation, scheduling and control framework. The production plan considers resource capacities, time periods, supply and demand over a reasonably long planning horizon at a high level.

Spares Availability – refers to the process of acquisition and ensuring the availability of maintenance spares and materials on site for the smooth flow of maintenance activities.

ABBREVIATIONS AND ACRONYMS

ATO	Assemble to Order
CBM	Condition Based Maintenance
GA	Genetic Algorithm
LRU	Line Replacement Units
MEMS	Micro-Electro-Mechanical Systems
MTBF	Mean Time between Failures
MWE	Megawatt electrical
NASA	National Aeronautics and Space Administration
NP	Non-deterministic polynomial
PDA	Preserving Data Aggregation
PDM	Predictive Maintenance
PM	Preventive Maintenance
RCM	Reliability-Centered Maintenance
RFID	Radio Frequency Identification Device
RFU	Ready for Use
ROC	Return on Capital
RTF	Run-to-Failure
RTM	Real-time Monitoring
SPSS	Statistical Package for Social Science
TPM	Total Productive Maintenance
TQM	Total Quality Maintenance

ABSTRACT

Machine condition plays a significant role on plant efficiency in the field of manufacturing. For this reason, maintenance has become an integral component of manufacturing. There are various methods of maintenance but preventive maintenance is key in maintaining the condition of plant equipment in manufacturers' state of operation. Preventive maintenance is scheduled and is based on principles of operations planning. However, research on how operations planning affect preventive maintenance in manufacturing companies remains a challenge. The general objective of the study was to establish how operations management planning affects preventive maintenance in Grain Milling Companies in Nakuru County, Kenya. The study used four objectives which were: Manpower planning, spares parts availability, production planning and plant layout. The target population for the study were grain milling companies which included, Unga millers, United millers, Mombasa maize millers and Milling corporation. The target population comprised of 226 technical staff directly or indirectly involved in machine maintenance. A sample of 113 was selected to participate in the survey using stratified random sampling technique. Questionnaires were used as the main data collection tool among the grain milling companies. Analysis of data was done using both descriptive and inferential statistics. Frequencies, percentages, mean and standard deviations were checked. Pearson moment correlation was used to establish the relationship between the independent and dependent variables and further to test the hypotheses of the study. Multiple regression analysis was used to determine the planning components that have greater impact on implementation of preventive maintenance. The findings of the study revealed that all the planning aspects had significant effects on preventing maintenance in grain milling companies. However spare parts availability, followed by manpower planning had the greatest impact on preventive maintenance in graining milling companies. The study therefore recommended that milling companies need to relook into their manpower planning especially for the preventive maintenance departments rather than focusing only on reactive breakdown staffing. Besides, milling companies should invest heavily in enhancing their sourcing strategies for their spare part. A separate inventory should also be maintained for preventive maintenance spares in line with maintenance schedules.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Maintenance management has grown throughout the years. Automation and mechanization at work place has led to a great reduction in the number of personnel and increased use of capital equipment (Garg & Deshmukh 2006). This has further led to increase of personnel in the area of maintenance leading to increase in the cost of operation. With an increase in such cost, there is need to determine efficiency in the manufacturing companies in terms of profit, manpower and materials.

To lessen the likelihood of failure of an equipment, it is important to regularly perform maintenance. Maintenance entails making periodic inspections to determine the operational condition of an equipment (Sullivan, Pugh, Melendez & Hunt, 2010). Preventive maintenance on the other hand entails replacing equipment components at intervals while calculating the potential operation lifetime. This is done to prevent breakdown of an equipment hence done when the equipment is still working. Prior planning has to be done if preventive maintenance is to become efficient. According to Levrat, Iungand Crespo Marquez (2008) maintenance management include all activities of management that are geared towards attaining the maintenance objective through the aspects of maintenance planning, control and supervision towards the wellbeing of organizations equipment

Today's complex and sophisticated systems need modern maintenance management systems. Condition based maintenance (CBM) had been used by many manufacturing firms. However, this is slowly changing where a new method of using the intelligent predictive decision support system (IPDSS) is currently being adopted (Yam, Tse, Li

& Tu, 2001). This new system predicts the trend of the descent of the equipment by providing reliable fault diagnosis of the equipment and gives it a self-life before it weakens. IPDSS is a form of preventive maintenance that can be used to pre-plan and also reschedule maintenance works thus reduces unplanned machine and equipment failure.

According to Garg and Deshmukh (2006) while looking at Maintenance management, they are of the opinion that preventive management ought to look at issues like optimization models, techniques to be used in maintenance, schedules and the information systems to be used.

While looking at management of wind power system, Nilsson and Bertling (2007) argue that there is need for frequent maintenance of wind turbines. To them, the current efficiency can be achieved if condition monitoring system (CMS) is adapted. This will lead to better maintenance and increased reliability. This monitoring system is also attractive as it can be used to determine specific maintenance timing.

In developing economies trends in maintenance appear to be different. According to Martin (2003), the main problem faced by developing and under developed countries is the lack of a proper maintenance culture. Maintenance perception and practice has also been significantly affected by culture in developing countries, which according to the world of maintenance embraces culture; some appears quite simple and others complicated. For modern day technologies, learning maintenance takes more time than putting them into practice. Thus, their implementation in most developing countries entails a certain level of literacy, a general skill of the personnel or workforce.

In most developing countries, it is a reality of life that maintenance education and training is hardly ever appreciated. Unfortunately for industries or firms in developing countries, effective maintenance is usually not a high priority and the consequent cost of failure as a percentage of total cost is on the rise. Gasskov (1992) cites as evidence of poor maintenance practices in developing countries that there is lack of proper maintenance in sectors such as housing, industries, public infrastructure which are characterized by wear off or become a public hazard.

The United Nations (2007) report on globalization Industrial Development for the 21st Century indicates that technology is becoming an increasingly important element of competitiveness and that the acceleration in the rate of technological change and the pre-requisites necessary to participate effectively in globalization have made it more difficult for many developing countries to compete. As a result, developing countries must develop more technological capability and greater flexibility to succeed in the more demanding and asymmetric global environment. One of the key aspects of dealing with technology is to have proper maintenance strategies that allow its sustenance.

In Kenya, majority of manufacturing companies give little emphasis on preventive maintenance. A study conducted among sugar firms in Kenya revealed that the priority given to preventive maintenance in sugar factories was less compared to other types of maintenance. Further, the maintenance tasks were found to have meaningful effects on the achievement of factory performance indicators (Mwanaongoro & Imbambi, 2014). Kwambai (2008) revealed that maintenance cost significantly affected the unit cost of geothermal energy thus affect the profitability of the plants.

In most Grain Milling Companies in Nakuru County, maintenance practice is based on total productive maintenance. In this system the company's focus on three major pillars that build up maintenance plan: Autonomous maintenance in which the basic maintenance is conducted by the operators. Here operators check on change in equipment performance, slight vibrations, overheating parts then call in maintenance personnel to rectify the abnormality. They also tighten loose parts, do cleaning of machine parts and tag any abnormality that needs to be rectified.

Secondly is the preventive maintenance (PM) which is handled by the maintenance personnel. These companies have a laid out structure for their PM where all the machines are scheduled into four categories of maintenance. These categories are: planned monthly- for basic maintenance conducted by maintenance team; Planned quarterly which is more advanced than planned monthly. Planned half-yearly-this is more of semi-overhaul of the equipment. Half of the machine critical parts are opened, serviced and returned back.

Finally, those planned yearly in which all the equipment is opened, all the parts checked for wear, serviced and returned back. Besides, some of the companies in the County employ Kobetsu Kaizen where they focus on repeated abnormalities; a team is formed, brain storms on causes of this abnormality and comes up with preventive and corrective countermeasures.

Preventive maintenance has to be planned before it is undertaken. This can result to increase in operational costs, low production during the maintenance period and increased production backlog. It is upon this back drop that the study sought to understand operations management planning and preventive maintenance in milling companies in Nakuru.

1.1.1 Operations Management Planning

Manufacturing firms have realized that higher profitability are tied within planning, organizing and supervision processes which make up for operations management. Organizational goals are usually set and regularly adjusted for the overall objectives to be met. Planning for operationalization of strategy takes varying processes hence each stage is treated with utmost importance (Stevenson & Hojati, 2007).

Operations management has its grounding on manufacturing firms where it was known as production management. Concentration of a service based industry led to integration of this concept in planning and organization. According to Slack, Chambers and Johnston (2010), Operations management ensures effective and efficient use of organizations input leading to output maximization. For this reason, planning for operations management needs to be tied together with preventive maintenance for manufacturing firms to reach efficiency and effectiveness.

Operations management and strategic planning have been widely researched however amalgamation of the two concepts as they complement each other is yet to be done. The extent of operations in strategic planning process and its impact need to be checked in relation to cost cutting and quality improvement aspects (Butler, Leong & Everett, 1996). Operation planning management thus is made possible by aspects like quality, flexibility delivery and cost control.

The major aim of operation production is the utilization of resources such as materials, personnel and facilities through the process of panning, coordination and control using the most optimal means. According to Stevenson and Hojati (2007) activities in production ought to be planned, coordinated, organized and controlled to meet the objectives of an organization. Planning in operations management will ensure preventive maintenance is properly undertaken.

1.2 Statement of the Problem

There is increased emphasis on maintenance function in most manufacturing firms. They attribute this emphasis on improved equipment reliability, increased productivity and quality of goods manufactured (Garg & Deshmukh, 2006). Due to this, managers in charge of maintenance have tried to coordinate their activities and align production schedules to fit with maintenance function. Aghezzaf, Jamali and Ait-Kadi, (2007) are of the view that for a long time there has been a conflictual relationship between production and maintenance. Lack of communication regarding the scheduling requirement of each function is attributed to strain in the relationship. Maintenance at times is not appreciated due to its consumption of time. Milling Companies in Nakuru County have tried to implement preventive maintenance strategies for enhancing equipment availability for production. The companies have invested heavily in maintenance workshops, tools, manpower, maintenance personnel protective equipment, internal & external trainings, E-maintenance systems and spares & consumables.

Despite the implementation and effort, grain milling firms in Nakuru have not been able to maintain a production schedule that can enable planning and adherence of timing and sizing requirements of production. It is expected that 10 years after its implementation, a feasible master production schedule should be in place to enable the maintenance manager be able to plan and schedule for production while carrying out maintenance work. The milling firms are at times still caught in reactive maintenance yet it is expected that preventive maintenance should have gained grounding ten years later (Lundvall & Battese, 2000). There is need to link maintenance planning function with aggregate production planning and master production scheduling activities. Grain milling firms are yet to realize that maintenance activities go hand in hand with production plan. Research on the factors contributing to the success of preventive maintenance in manufacturing firms in Kenya remain blurred. Therefore, this study sought to analyze the role played by operations management planning on effective of preventive maintenance in Milling Companies in Nakuru County, Kenya.

1.3 Research Objectives

The study was guided by the following objectives.

1.3.1 General Objective

The general objective of the study was to establish the effects of operational planning on preventive maintenance in Grain Milling Companies, Nakuru County-Kenya.

1.3.2 Specific objectives

The specific objectives to the study were as follows.

1. To establish the effect of manpower planning on preventive maintenance in Grain Milling Companies in Nakuru County
2. To assess the effect of spares part availability on preventive maintenance in Grain Milling Companies in Nakuru County
3. To determine the extent to which production planning affects preventive maintenance in Grain Milling Companies in Nakuru County
4. To analyze the effects of plant layout on preventive maintenance in Grain Milling Companies in Nakuru County.

1.4 Research Hypotheses

1. **$H_0: \mu_1 = \mu_2$ $\mu_1 - \mu_2 = 0$** Manpower planning has no effect on preventive maintenance in Grain Milling Companies in Nakuru County.
2. **$H_0: \mu_1 = \mu_2$ $\mu_1 - \mu_2 = 0$** Spares part availability does not affect preventive maintenance in Grain Milling Companies in Nakuru County.
3. **$H_0: \mu_1 = \mu_2$ $\mu_1 - \mu_2 = 0$** Production planning has no influence on preventive maintenance in Grain Milling Companies in Nakuru County.
4. **$H_0: \mu_1 = \mu_2$ $\mu_1 - \mu_2 = 0$** Plant layout does not affect preventive maintenance in Grain Milling Companies in Nakuru County.

1.5 Significance of the Study

The study revealed how operational planning affects preventive maintenance in Grain Milling Companies in Nakuru County and in Kenya at large. The findings therefore shed light on how planning and preventive maintenance could be used to improve the performance of manufacturing sector which is one of the largest sectors in the economy. By determining how planning can be used as a strategy for enhancing efficiency in preventive maintenance in Grain Milling Companies, this could help improve the machine availability and productivity of the company therefore improving shareholder returns and wealth as well.

The study was also important to the management of Grain Milling Companies by providing an insight on the effectiveness of preventive maintenance and the planning factors contributing to its success or failure. These if implemented would help improve the reliability, efficiency and productivity of the plant equipment thus minimize production costs in the companies thus improving on profitability. The findings would also benefit other production firms by providing guidelines on manpower planning, production planning and procurement planning of spare parts on implementation of preventive maintenance.

1.6 Scope of the Study

This study was conducted in four major Grain Milling Companies in Nakuru County, Kenya. It covered the maintenance team, production supervisors, managers and engineers. The study sought to assess manpower planning, spares availability, production planning and plant layout on preventive maintenance.

1.7 Limitations of the Study

There are few empirical studies conducted in Kenya that relates to preventive maintenance on gain milling companies. This implied that the study did not have sufficient local literature and studies to infer their findings. The researcher overcame this challenge by focusing on other cases of manufacturing organizations outside the country as there are lots of similarities in maintenance practices across the industry. Secondly, the practice of preventive maintenance was not well known to all staff of Nakuru County’s Grain Milling Companies. Therefore, this study focused on those staff in the maintenance departments and in the technical departments that support or work hand in hand with maintenance department.

1.8 Organization of the Study

This study was divided into five chapters. The first chapter on introduction introduced the reader to the concept under investigation by providing the background of the study, problem of the study, research objectives and questions, significance of the study, scope and assumptions of the study. The second chapter on literature review presents the theoretical literature to guide in the conceptualization of the study as well as empirical studies on the same. The variables of the study are also outlined in the conceptual framework. The third chapter on research methodology presents the methodology that was used in conducting the study by outlining the research design, population of study as well as the sample and sampling design. The data collection tools and methods of data collection and analysis are discussed. The fourth chapter presents an analysis of research findings and presents the results while chapter five draws discussions, conclusions and recommendations based on the study findings.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the literature review for the study. The literature is organized in three components: theoretical review, conceptual review and empirical review. A critique of empirical studies is also presented and a summary of research gaps.

2.2 Theoretical Review

The study was guided by theories and models in maintenance such as the replacement theory, reliability centered maintenance theory, maintenance contribution model and the DuPont model.

2.2.1 Replacement Theory

The replacement theory was developed by (Nahmias, 1997). The replacement theory is generally concerned with the problem of replacement of machines, bulbs and men due to deteriorating efficiency, failure or break down. The theory states that, replacement is usually carried out under the following situations: When existing items have outlived their effective lives and it may not be economical to continue with them anymore or when the items might have been destroyed by accidents or otherwise.

There are two approaches to the replacement theory: the quantity-based replacement policy and time-based replacement policy for a single machine problem. In a quantity-based replacement policy, a machine is replaced when an accumulated product of size q is produced. In this model, one has to determine the optimal production size q. While in a time-based replacement policy, a machine is replaced in every period of T. For this model, one has to determine the optimal replacement period T in each production cycle.

In the context of the current study, the replacement theory would be useful in determining the approach in machine replacements to be used in machine maintenance. This could be based on the quantity produced by certain machine parts or even the time that a particular machine has been able to run. The two approaches are critical in decision making and planning for maintenance. The study would also seek to understand the approach used and its application at the Grain Milling Companies.

This theory is useful in that it explains when machines and equipment should be replaced. Further manpower planning and spare part availability can be explained by the two approaches of the replacement theory. When the quantities of spare parts are available and when the replacement duration reaches, then it is prudent for any grain milling firm to effect replacement.

2.2.2 Reliability Centered Maintenance Theory

Reliability-Centered Maintenance (RCM) has its root in the airline industry. It was further developed by Nowlan and Howard (1978). It is the process of determining the most effective maintenance approach. The RCM philosophy employs Preventive Maintenance (PM), Predictive Maintenance (PdM), Real-time Monitoring (RTM1), Run-to-Failure (RTF- also called reactive maintenance) and Proactive Maintenance techniques in an integrated manner to increase the probability that a machine or component will function in the required manner over its design life cycle with minimal maintenance. The goal of the philosophy is to provide the stated function of the facility, with the required reliability and availability at the lowest cost. RCM requires that maintenance decisions be based on maintenance requirements supported by sound technical and economic justification.

Reliability Centered Maintenance originated in the Airline industry in the 1960's following a task force that was formed consisting of representatives of both the airlines and the National Aeronautics and Space Administration (NASA) to investigate the capabilities of preventive maintenance (NASA, 1968). The establishment of this task force subsequently led to the development of a series of guidelines for airlines and aircraft manufacturers to use, when establishing maintenance schedules for their aircraft. This led to the 747 Maintenance Steering Group document, a handbook: Maintenance Evaluation and Program Development from the Air Transport Association in 1968. Reliability centered maintenance is based on the principles of: function oriented, system focused, reliability centered, and driven by safety and economics, and uses a logic tree to screen maintenance tasks (Nowlan & Heap, 1978). According to the theory, decisions made early in the acquisition cycle profoundly affect the life-cycle cost of a facility. Even though expenditures for plant and equipment may occur later during the acquisition process, their cost is committed at an early stage. The principles of reliability are key components that guide planning in preventive maintenance in the case of Grain Milling Companies.

2.2.3 Maintenance Contribution Model

The maintenance contribution model was developed by Vansteeland & Gelders (1981) based on the fact that various maintenance policies incorporating a range of scheduled maintenance activities impact the number of times a piece of equipment fails. The change in the number of failures changes the mean time between failures (MTBF) and downtime for repair, thereby impacting equipment availability. The change in availability allows the company to vary its output level, which in turn affects sales revenue and production costs. Maintenance costs are also affected as the level of emergency and scheduled maintenance activities vary. The changes in revenue and costs impact profit and ROC. In this study, the model is helpful in explaining the economic impact of preventive maintenance in the Manufacturing sector in Kenya especially at the Grain Milling Companies.

2.2.4 The DuPont Model

The DuPont model provides a means for the maintenance department to communicate alternative maintenance policies to top management. By taking operational information such as production levels and downtime and dollarizing them within the DuPont model, management can review the various maintenance options in terms of the company's financial performance. The DuPont model is, however, not without its drawbacks. Financial ratios are limited since they can be distorted by a company's operating and accounting procedures. Although financial analysts do not always look upon the DuPont model favorably, its only purpose in this study is to provide evidence that maintenance significantly affects the company's financial standing (Weston and Brigham, 1987). The numerical values used within the DuPont model are modified from an example in Brigham and Gapenski (1987). The values in this example are modified to achieve approximately a 9% return on capital as a base case when used with the company's hourly maintenance cost data. Changes in the ROC are due to the maintenance policies' impact on production levels which are used to calculate revenue and production costs. In addition, maintenance costs vary as the alternative policies are examined. Both production and maintenance costs are incorporated into the model as direct costs.

The capital portion of the DuPont model is not affected in this study. Nevertheless, management might expect to see a shift between inventories and cash. If the maintenance policy reduces the number of expected failures, less work-in-process and finished goods inventories are required to cover these unanticipated breakdowns. In addition, by planning and controlling more of its maintenance activities, management can reduce its investment in maintenance, repair and operating inventories. These savings can be reflected in extra cash or invested in s with a higher rate of return than inventories (Rishel, 1991). The potential for additional cash may be important for a company since profit does not determine a company's solvency. Maintenance is one more factor a firm can incorporate into its cash planning practices as well as its overall business strategy (Sullivan, et al., 2010). The DuPont model provides an important strategy for generating important operational data in maintenance as well as in explaining the economic impact of equipment maintenance hence it would be necessary in the current study.

2.3 Empirical Review

This section looks at past studies done in relation to the variables of the study. The studies are from all over the globe and they help us understand what other researchers have done hence helps in building up on the research gap of this study.

2.3.1 Manpower Planning and Efficiency in Preventive Maintenance

Pintelon and Gelders (1992) indicate that decision making remains key to man power planning. To them management of industrial design is important yet it is still much neglected. Man power planning entails planning for management planning in operations management environment, decisions to be undertaken and the tools to be used.

Kim and Yoo (2012) look at the combined manpower planning and preventive maintenance strategies by aggregate planning for the service division of vending machines. The mathematical model used is aimed towards planning of work force size and preventive maintenance. The model used helps in identifying two types of machine failure that need different repair and preventive maintenance. They argue that this model is effective in reducing the total cost while at the same time it improves the quality of service which in turn improves the overall system performance.

Budai, Dekker and Nicolai (2006) gives a review of planning models for maintenance and production. They start by giving the relation between planning of maintenance and production. to them, production planning and schedule models were never successful thus necessitating the aspects of maintenance. In their study, they give priority to preventive and corrective maintenance as part of manpower planning. Opportunity maintenance is proposed where the items to be maintained are less needed for production.

Manpower planning has shift its focus from manpower planning to the knowledge era. According to Samoff and Carrol (2003) the work of education was to develop skills that were needed in African countries. This led to manpower planning, which has been constantly changing to accommodate rate of return of the input by the manpower. Knowledge is becoming the most important factor of production where manpower has to be planned for and additionally the manpower has to translate its output into a tangible investment that can be counted back as profit.

According to Subramaniam, Husin, Yusop and Hamidon (2008) manpower utilization and machine efficiency contribute to production line efficiency. They thus advocate measuring of machine efficiency and manpower planning to be accurate to enable organizations make accurate projections too. When machines are not maintained properly, they result into increased maintenance costs and low standards of production (Konopka & Trybula, (1996). Maintenance activity require close attention of the management to work together with the appropriate personnel in ensuring machines are used as required and further reduce on machine wastage due to machine stoppage.

Subramaniam, et al, (2008) further continue to indicate that human beings are important in ensuring organizational targets are met. Their paper divides humans into two categories; operators in production line and workers in the supporting department. The latter deals with the processes in the industries. Capability and duration of work makes human performance to vary, a drop in performance leads to a drop in output produced. To increase production, there is need to properly monitor workers. Subramaniam, et al, (2009) are of the opinion that the attitude of workers is crucial in ensuring maximum productivity is reached and a reduction in planned production time.

Knapp and Mahajan (1998) while looking at optimization of maintenance organization and manpower in process industries, are of the opinion that maintenance manpower planning's major objective is to have right number of workers with needed capabilities in maintenance areas. In their study, the manpower was accorded categories such as maintenance area, craft type, training levels, in house verses contractual agreement and lastly centralized verses decentralized system while trying to come up with the most ideal type of manpower to use at work place.

Kryshkevych (2013) concentrate with the study on a flexible approach to effective and efficient manpower planning for Ukraine International Airlines at main station Boryspil International Airport. To him there is need of developing a strategic manpower planning model which should be flexible enough. With this model, he is of the view that capacity planning issues related to manpower scheduling and requirement can be solved.

.2.3.2 Spares Part Planning and Efficiency in Preventive Maintenance

Kumar and Knezevic (1998) look at the availability based spare optimization using renewal process. The paper has developed a mathematical model for spare part components. Through use of the model, a prediction of the required number of spare parts for a system to achieve specified inherent availability can be done. Optimization here is used to check on the system's cost and weight.

Kennedy, Patterson and Fredendall (2002) gives an overview of recent literature on spare parts inventories. To them, any inventory in spare part is not a final product to be sold to customers. Spare parts inventory policies are different from those that govern work in progress (WIP) and other inventories. They give unique features of spare part inventories. The literature in this study concentrates on management issues, replacement basing on the age of the equipment, obsolesce problems and the spare parts to be repaired. The study concludes by indicating a need for future research need for spare parts and preventive maintenance subject matter.

The study carried by De Smidt-Destombes, van der Heijden and van Harten (2004) concentrates on limited spares and repair capacity using a condition based maintenance strategy. To them, failed components that surpasses the critical levels calls for maintenance of an equipment. There is usually a set up time that calls for all replacement of components by spares. Availability of a system will largely depend on three components, these are: spare part stock level, maintenance policy and repair capacity.

Ilgin and Tunali (2007) conduct a study on joint optimization of spare parts inventory and maintenance policies using genetic algorithms. It is first noted that in industries, maintenance and spare parts inventories are treated separately or in a sequence. They are of the view that stock level of spare parts depends on maintenance policies. They thus propose a simulation optimization approach using genetic algorithms (GAs) where joint optimization of preventive maintenance (PM) and spare provisioning policies of a manufacturing system operating in the automotive sector can be introduced. The study conducted a factorial experiment with the aim of identifying the parameters that could be used for GA. These included: probabilities of crossover and mutation, the population size, and the number of generations. Through the study, it was concluded that there is a significant cost reduction and an increase in the throughput of the manufacturing system using the given parameters.

De Smidt-Destombes, van der Heijden and van Harten (2009) in a different study look at joint optimization of spare part inventory, maintenance frequency and repair capacity for k-out-of-N systems. To them, there is need to make relevant decisions on the choice of frequency of preventive maintenance, spare part inventory levels and spare part repair capacity a high system with minimal costs is to be achieved. To them inferior results are yield by an extension of the metric method as both the availability and costs are not necessarily monotonous functions of the decision variables. The study thus recommends that there is need for an adjusted marginal analysis as this leads to better numerical experiments.

According to Lanza, Niggeschmidt and Werner (2009) the operational conditions of machines determines how reliable a machine becomes. In their study of optimization of preventive maintenance and spare part provision for machine tools based on variable operational conditions, they suggest that the intervals between the maintenance and provision of spare parts need to be adapted to individual load collective if the reliability of the machine is to be achieved. According to this study, there lacks a comprehensive approach that can quantify how loads are effected and further ensure the given actions have been adapted. Using a stochastic optimization algorithm reliability model the paper gives a suggestion how optimal time for preventive mechanism and spare part provision can be done.

Rausch and Liao (2010) look at the Joint production and spare part inventory control strategy driven by condition based maintenance. In their study, they monitor reduction in performance of a critical unit. Replacement action using spare part inventory control and due date constraints are initiated as a result of degradation. To manage the manufacturing process, there is need to combine both degradation limit maintenance policy and a base stock spare part inventory control policy. This is done to reduce on the spare part inventory and the total operating costs.

Louit, Pascual, Banjevic and Jardine (2011) looks at condition-based spares ordering for critical components. To them, there is need for an interval between identification of potential failure and the actual failure. This needs to be longer than the lead the required part. For a spare part to be ordered, there is need to critically look at the remaining useful life of the spare part. This can be obtained through use of two important criteria; assessing the age of the component and use of condition indicators.

Nosoohi and Hejazi (2011) uses a multi-objective approach to simultaneous determination of spare part numbers and preventive replacement times. They note that the focus of previous studies was on classical cost objective. They depart from that approach and instead look at a multi objective model for preventive replacement of a part over a planning horizon. In this model, different objectives are considered. They further give practical solutions for the challenges faced in the different objectives. Through its initial planning phases, number of spare parts can be determined. The model is applicable in equipment that requires replacement of faulty parts. They further use a numerical example to indicate how preferred solutions can be reached in the absence of a decision maker.

Wang (2011) on the other hand undertakes a study on the joint spare part and maintenance inspection optimization model using the delay-time concept. They are of the view that spare parts and maintenance are closely related activities where Maintenance generates the need for spare parts. Planned preventive maintenance activities leads to the need for more spare parts. The paper thus advocates for optimization of decision variables like ordering quantity, ordering interval and inspection interval. Using the delayed time concept, the failure process is divided into two-stage process with the intention of optimizing the expected cost per unit time using the three variables given. Using a block base inspection policy, checking of components is done at the same time notwithstanding the ages of the components. From this exercise, the time of failure which is known as forward time can be detected.

2.3.3 Production Planning in Preventive Maintenance

Uzsoy, Lee and Martin-Vega (1992) conducted a review of production planning and scheduling models in the semiconductor industry. Industrial engineering operations have begun to address the problems of production planning and scheduling. The features of such projects include: random yields and rework, complex product flows, and rapidly changing products and technologies. Due to the challenging and problematic nature of the projects, the solutions provided will enable a contribution to the die theory and further lead to the practice of production planning and control.

Ciarallo, Akella and Morton (1994) in their periodic review of production planning model with uncertain capacity and uncertain demand indicate that factors leading to uncertainty in production include: Increasing product complexity, manufacturing environment complexity and an increased emphasis on product quality. The uncertainty presents themselves in form of unplanned machine maintenance, varying production yields and rework, among others. They thus argue that while planning for production there is need to come up with a model that can incorporate all the mentioned uncertainty into the production process.

Van der Laan and Salomon (1997) study is on production planning and inventory control with remanufacturing and disposal. Production of new products or remanufacturing must fulfil customer's demands. They advocate push and pull strategies that can be used in coordination of production remanufacturing and disposal operations. Further their paper suggests the importance of planned disposal and their economic benefit and how they should be used. A discussion of the strength of the push and pull disposal strategy over the different stages of a product life has been given.

Departing from Van der Laan and Salomon study of (1997). Guide (2000) looks at Production planning and control for remanufacturing: industry practice and research needs. He argues that there is high concentration on value added recovery rather than material recovery. Remanufacturing is gaining prominence in United States but it should be noted that its management of production planning and control activities are very different from traditional manufacturing. They are further more complex due to uncertainties from stochastic product returns, imbalances in return and demand rates, and the unknown condition of returned products.

Cassady and Kutanoglu (2005) look at integrating preventive maintenance planning and production scheduling for a single machine. They talk of the interdependence of the two concepts of preventive maintenance planning and production scheduling. They note that available production time is affected by both preventive maintenance and repair yet most literature usually ignore this interdependency. A proposal is made on an integrated model to minimize on the time used to finish a particular task. Their study thus uses small scheduling problems to conduct an experimental study. A comparison between the performance of the integrated solution with the solutions obtained from solving the preventive maintenance planning and job scheduling problems independently is done. Their study indicates that integrated preventive maintenance planning and production scheduling should be focused on critical machines.

Stevenson, Hendry and Kingsman (2005) put their concentration on classical approaches to production planning and control (PPC) using models like Kanban, Manufacturing Resource Planning (MRP II) and Theory of Constrains (TOC). According to the authors, applicability in planning and control is made possible by factors such as importance of the customer enquiry stage, company size, degree of customization and shop floor configuration. Through this paper, researchers and practitioners are made aware of PPC options, its helps in decision making by managers and further helps in learning on the importance of clear implementation strategy.

Models for production planning under uncertainty is looked at by Mula, Poler, Garcia-Sabater and Lario (2006). Uncertainty is taken as a serious issue in manufacturing system. The models used thus should account for this uncertainty as it guarantees good planning decisions. The paper comes up with a classification scheme which can be used for production planning under uncertainty.

Aghezzaf, Jamali and Ait-Kadi (2007) study is based on an integrated production and preventive maintenance planning model. It is hypothesized that that there is need for mass production throughout a given time frame. Random system failures are bound to happen and any maintenance action carried during this period is bound to reduce production period. They suggest that for the objective of production without system failure happening, there is need for an integrated production and preventive maintenance system that satisfies the demands of manufacturing firms. Their solution is in planning for a system that undergoes periodical renewal and repairs are not done at machine failures. They give detailed steps of achieving their proposals.

While looking at integrated production planning and preventive maintenance in deteriorating production systems, Aghezzaf and Najid (2008) look at a system that is composed of parallel failure prone production lines. Failure of a production line will lead to repairs which restores the production line to a working condition but this cannot be termed as the perfect condition. Preventive maintenance on the other hand which is done at the decision maker's discretion restores the production line to a better status. The two authors assume that during maintenance action, production capacity is reduced temporarily. There is therefore need for cyclic preventive maintenance to prevent reduced production in manufacturing firms. This situation calls for planning to ensure performance and production are maintained.

Najid, Alaoui-Selsouli and Mohafid (2011) while looking at an integrated production and maintenance planning model with time windows and shortage cost. These areas over time have been treated independently which have led to independent models for each function. There is therefore need to integrate all the models as they are integrated to bring solutions that are optimal. Integrating these models further leads reduced operational costs and increased productivity.

Fitouhi and Nourelfath (2012) on the other hand looks at integrating noncyclical preventive maintenance scheduling and production planning for a single machine. This study is different from (Cassady Kutanoglu, 2005) as they zero down to noncyclical preventive maintenance. According to their maintenance policy, there ought to be preventable replacement at beginning of each production planning period while minimal repairs of machine failure should be realized. The idea of the plan is to have minimum costs across the board. These costs include: preventive and corrective maintenance costs, setup costs, holding costs, backorder costs and production costs. The demands for all the products must be met across the production period. The findings indicate that amalgamation of maintenance and production planning can reduce the total maintenance and production cost and the removal of periodicity constraint.

2.3.4 Plant Layout and Efficiency in Preventive Maintenance

Gupta and Seifoddini (1990) argues that almost a third of companies in the US reorganize their plant layouts every two years. Lately, most researchers are alive to the idea of dynamic layout problems that considers changes in material handling flow over a period of time – weekly, monthly or yearly. The two main types of layout considered are static and dynamic layout.

Heragu and Kakuturi (1997) looks at plant layout as on organization of all the essential machines, workspace, production unit, department etc. for production of goods and service delivery thereof for ultimate efficiency maximization and cost minimization. The primary objective of plant layout is to maximize profit of all facilities to best advantage of sum manufacturing of the product.

A continuous assessment of the variations in product demands and interlinkage between departments. According to Baykasoglu & Gindy, (2001) preventive maintenance cost should be considered a vital factor while modifying or planning plant layout.

Maximization of profits is the major goal of plant layout, all facilities are arranged in such a way that will enable best advantage of manufacturing be undertaken (Abdi & Labib, 2004). Organizations undertake plant layout with the intention of streamlining flow of materials through the plant, help in the manufacturing process. Ensure availability of inventory, reduce the cost of handling materials, utilization of personnel, equipment and space among other reasons.

Lee, Brzezinski and Ni (2011) in the publication reckon that plant layouts at design inception are never comprehensive enough given the dynamic production demands in increasingly evolving environment/market. In essence the inflated constrain and cost of production makes it important to have a plant layout with a single production line with several set (s) of stations. Further, plant layouts are revised/ re-designed from time base on the increase, decrease or diversification in production in keeping with preventive maintenance and the cost consideration.

2.4 Summary of Research Gaps

Author	**Focus of Study**	**Findings**	**Research gaps**	**Focus of current study**
Budai, Dekker and Nicolai (2006)	Planning models for maintenance and production	Preventive and corrective maintenance is important in production planning and scheduling models.	Priority given to preventive and corrective maintenance while overlooking production planning and scheduling models.	Operations management planning and preventive maintenance.
Subramaniam, Husin, Yusop and Hamidon (2018)	Machine efficiency and man power utilization on production lines	There is need for accurate measure of machine efficiency and manpower planning to enable organizations make accurate projections.	Personnel to carry out maintenance and their timings for maintenance was not critically looked at.	Operations management planning and preventive maintenance.
Kryshkevych (2013)	Flexible approach to effective and efficient manpower planning.	There is need of developing a strategic manpower planning model which should be flexible enough.	Capacity planning is looked at while other factors for planning are ignored.	Operations management planning and preventive maintenance.
Kennedy, Patterson and Fredendall (2002	an overview of recent literature on spare parts inventories	Any inventory in spare part is not a final product to be sold to customers	There can be a confusion of Work in progress and spare parts inventories.	Operations management planning and preventive maintenance.

2.5 Conceptual Framework

The effects of planning on effective preventive maintenance in production can be summarized in a conceptual model on figure 2.1.

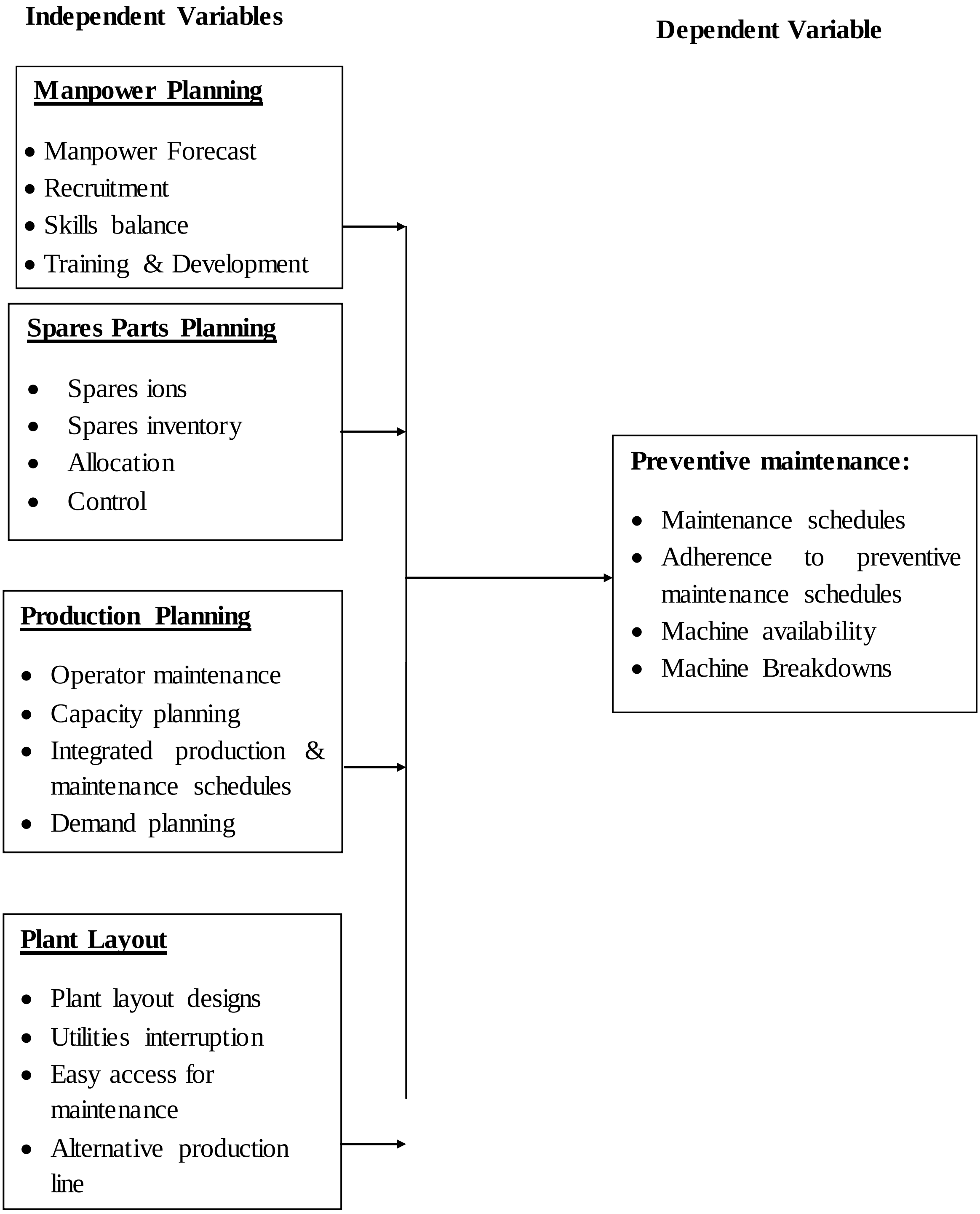


Figure 2. 1: Conceptual Framework
Source: Author (2017)

The study hypothesized that effective preventive machine maintenance is as a result of proper planning for the event since the main objective of PM is to have proactive measures that would minimize machine breakdown and enhance performance. The planning is based on four broad areas: Manpower planning to ensure availability and proper utilization of maintenance team. Spares planning would ensure that the maintenance department anticipates the expected spare parts to be used ahead of machine overhaul to ensure that machines do not stall waiting for spare parts. Production scheduling on the other hand ensures that maintenance is effectively implemented alongside the production period or in between production schedules therefore not disrupting production. Equipment planning ensures proper utilization of equipment and capacities during production.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the methodology and procedures that were followed in conducting the study. It contains the design for the study, study population, sampling frame, study sample and sampling techniques, data collection instruments, procedures, pilot testing and data processing and analysis procedures.

3.2 Research Design

A survey design was used for the study with the main focus being on Grain Milling Companies in Nakuru County. This design is preferred because it provides for a wider coverage of the industry therefore enable generalization of results (Bryman & Bell, 2011). By applying this design, the study provided in depth insights on the relationship between planning and effective implementation of preventive maintenance in production at Grain Milling Companies.

3.3 Target Population

The study target population comprised the 226 technical staff of four main grain milling companies in Nakuru County Namely: Unga Limited, United Millers, Milling Corporation and Mombasa Millers. The technical staff include the: maintenance engineers, maintenance technicians, fitters, production managers, production supervisors and technical procurement team. The distribution of the target population was as follows:

Table 3.1: Distribution of the Target Population

	Maintenance Engineers	Maintenance Technicians	Fitters	Production Supervisors	Technical Procurement staff
Unga Limited	5	22	36	4	3
United Millers	4	19	27	3	2
Milling Corporation	6	27	25	6	2
Mombasa millers	3	13	16	2	1
Total	18	81	104	15	8
		Total = 226			

Source: Kenya Association of Manufacturers (2016)

3.4 Sample Size and Sample Design

The sample size for the study was determined based on the guideline by Mugenda & Mugenda (2003). According to him 50% of the study population provides a sample size that can be considered adequate enough. This brought the sample size to 113 Technical staff in grain milling companies. Distribution of the study sample was as shown on Table 3.2.

Table 3. 2: Distribution of Study Sample

	Maintenance Engineers	Maintenance Technicians	Fitters	Production Supervisors	Technical Procurement staff
Unga Limited	2	11	18	2	2
United Millers	2	9	13	2	1
Milling Corporation	3	13	12	3	1
Mombasa millers	2	7	8	1	1
Total	9	40	51	8	5
		Total = 113			

Source: Research Data (2017)

The selection of study sample was done using stratified random sampling technique in which the strata was based on individual companies.

3.5 Data Collection Instrument

The study collected primary data from the technical staff in Grain Milling Companies using the questionnaire. Questionnaires were preferred in this study because they allow investigation with an ease of accumulation of data in a highly economical way (Graveter & Forzano, 2003). The tool was designed with four sections based on the research objectives. The questionnaires were designed using both open ended and closed ended questions. Respondents' opinions were measured on a five point likert scale.

3.6 Piloting Test

The data collection tools were piloted in a sample of 5 selected technical staff of the United Millers in Nakuru. The company was preferred because majority of the manufacturing processes, products and equipment are similar to those of other Grain Milling Companies thus it formed a suitable ground for piloting.

3.6.1 Validity of the Instrument

Jackson, & Marshall (2007) defines validity as the strength of conclusions and inferences of a research, which is dependent on the degree of accuracy in measuring what is intended in the research. An item analysis of the questionnaires was done to see whether the items in the instruments belong there, so as to minimize on vagueness of the questions to be generated. Content validity was accomplished through expert judgment where the study and the instruments were subjected to the opinion of research supervisors at Kenyatta University.

3.6.2 Reliability of Instrument

Reliability according to Mugenda and Mugenda (2003) is a measure of the degree to which research instruments yield consistent results or data after repeated trials. To improve on reliability in this study, Piloting questionnaires were analyzed using Cronbach's reliability coefficient. Table 3.3 presents the findings of the study

Table 3.3 Reliability Statistics

Variable	No of Items	Cronbach Apha
Effect of manpower planning	10	.796
Effect of spares part availability	13	.827
Production Planning	19	.756
Effects of Plant layout	7	.713
Preventive Maintenance	8	.776

According to George and Malley (2003) an alpha value of below 5 is unacceptable, a value of 5 is poor, 6 is questionable, 7 is accepted, 8 is good while 9 is excellent. The closer the coefficient is towards 1.0 the greater is the internal consistency of the items on scale.

3.7 Data Collection Procedure

In order to obtain authority to conduct the study, the researcher first obtained an introductory letter from the Kenyatta University. This was used to obtain research permit from the National Commission for Science Technology and Innovation. This was then used to seek a research authorization letter from the management of Grain Milling Companies. The researcher then personally paid field pre-visit to meet with the various heads of technical staff to understand the distribution of staff across shifts and to book appointments. Sampling was then done and questionnaires distributed to the sampled respondents using the drop and pick later method.

3.8 Data Analysis Procedure

Raw data from the field was first cleaned then coded before being entered into the computer for analysis using Statistical Package for Social Sciences (SPSS) version 21.0. Data cleaning in research is an important stage of verifying that the data values are correct or, at the very least, conform to some set of rules (Bartholomew, Steel, Moustaki & Galbtaith, 2008). Coding on the other hand converts ranked data to numerical figures for easy analysis using quantitative tools. The choice of SPSS 21.0 in handling and analyzing data were made because it is easy to run, time saving and contains all the statistical analysis tools required in the study. Both descriptive and inferential statistics were used.

Analysis of data was done according to the research objectives: to analyze each objective, responses were summarized into frequencies and percentages, and a computation of the mean for the purposes of weighting them. In addition, the multiple regression analysis was used to determine the contribution of the various aspects of operational planning on preventive maintenance at Grain Milling Companies. The regression was based on the model below:

$$Y = \alpha_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon_0$$

Where:	Y	= Preventive Maintenance
	$\beta_1, \beta_2, \beta_3, \beta_4$	= Coefficients of the independent variables
	X_1	= Manpower planning
	X_2	= Spares planning
	X_3	= Production planning
	X_4	= Equipment planning
	α_0	= Constant
	ε_0	= Error Term

3.9 Ethical Considerations

Before commencing data collection, ethical clearance was sought and obtained from the graduate school of Kenyatta University. Further, the researcher obtained permits and permission to conduct the study from the management of Grain Milling Companies in Nakuru County. Besides, the researcher sought for the informed consent of participants before the study. Specifically, participants were informed through the introductory letter about the purpose and objectives of the study. Their participation was voluntary. No names of the study participants were recorded in the questionnaire to ensure confidentiality.

CHAPTER FOUR

DATA ANALYSIS, INTERPRETATION AND DISCUSSION

4.1 Introduction

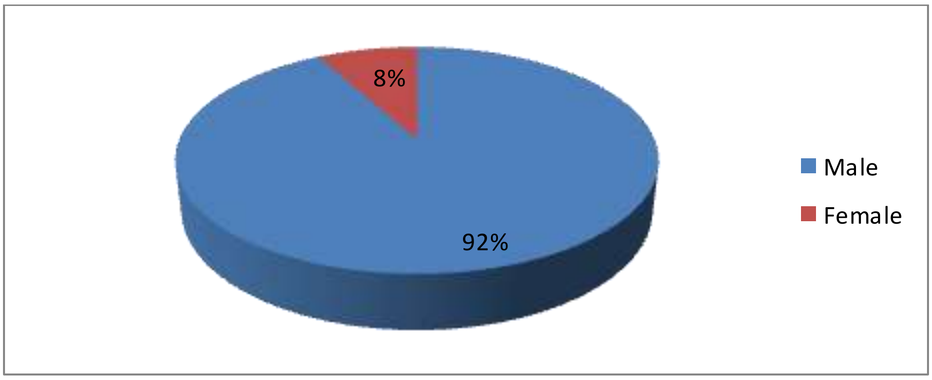
This chapter presents the results of data analysis for the study. Findings were presented and discussed based on the research objectives. The researcher distributed 113 questionnaires to technical Staff in grain milling companies in Nakuru County. However, the questionnaires that were filled and returned were 106. This implies that the study achieved a questionnaire return rate of 94.64%.

4.2 Respondents Demographic Information

Several demographic characteristics were determined for the technical staff who took part in the study. These included their gender, age, designation, education level and work experience in the company. The findings are presented and discussed in the following sub sections.

4.2.1 Gender of Respondents

The study considered gender of technical staff. This was used to determine whether technical staff in grain milling companies' distribution aligns with the constitutional two thirds gender rule in Kenya. Figure 4.1 shows the findings.



Source: Survey Data (2017)

Figure 4.1: Gender of Technical Staff

From the findings in Figure 4.1, majority 92 % of the technical staff were from the male gender while 8 % were female. This shows that the grain milling companies did not observe the two thirds gender rule in staffing their technical departments or the female gender did not take up careers in technical jobs.

4.2.2 Age of Respondents

The age of technical staff was also determined on a continuous scale by asking the technical staff to indicate it. The researcher then categorized the ages and presented them as follows in Table 4.1. It is important to note that age plays a critical role in determining the experience of technical personnel.

Table 4.1 Age of Respondents

	Frequency	Percent
18- 25 years	3	3
26- 35 years	37	35
36-45 years	27	25
46- 55 years	29	27
56 years and above	10	10
Total	106	100.0

Source: Survey Data (2017)

Most of the respondents (35%) were between the ages of 26- 35 years. This was followed by 27% who were between the ages of 46-55 years. The least age was 18-25 years which had only 3%. From the findings, it could be deduced that most of the employees were relatively between youthful and middle aged hence were energetic and could lead to positive contributions during the preventive maintenance processes at their work place.

4.2.3 Job Designation

This section was meant to determine the job designation of the participants of the study across the realms of technical works in manufacturing. The findings are presented in Table 4.2.

Table 4.2: Job Designation

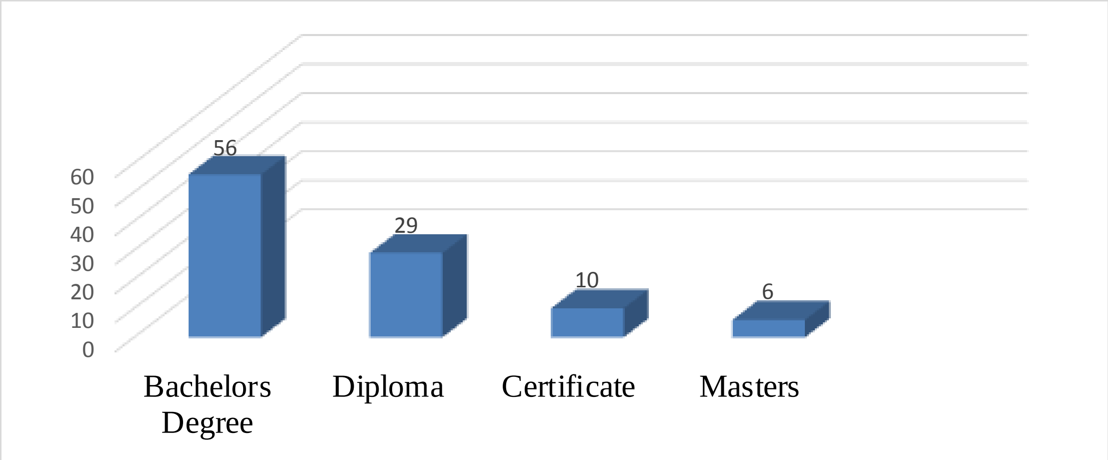
Job Designation	Frequency	Percent
Maintenance Engineer	7	6.60
Maintenance Technician	39	36.79
Fitter	49	46.22
Production Supervisor	7	6.60
Technical procurement staff	4	3.77
Total	**106**	100

Source: Survey Data (2017)

According to the findings in Table 4.2 majority of the persons targeted for the study responded to the questionnaires. As a result, the responses comprised of 6.6% maintenance engineers, 36.79% maintenance technicians while 45.22% were fitters. Besides the production team was represented at 6.6% by production supervisors while the technical procurement team was represented by 3.77%. This implies that the opinions presented in this study included the entire team involved in preventive maintenance works either directly or indirectly. Arca and Prado (2008) are of the opinion that Personnel participation is a key factor for success in maintenance program implementation. The findings thus have proved to be in line with other previous studies.

4.2.4 Education Level of Technical Staff

Education level of technical teams in grain milling companies was determined and presented in figure 4.2. Education level is a key ingredient in determining the competency of staff and their capacity to handle preventive maintenance works.



Source: Survey Data (2017)

Figure 4.2: Education Level of Technical Staff

The distribution on education level of technical staff in Figure 4.2 shows that majority (56%) were bachelor's degree holders followed by 29% who were diploma holders. Besides, 5.66% held master's degree while a small percentage (10 %) had certificate level of education. This indicates that the respondents could be able to interpret the context of the questionnaire. Kongsved, Basnov, Holm-Christensen and Hjollund (2007) while looking at response rates and completeness of questionnaires views that increased level of education reduces errors in filling of the questionnaires which translates to interpretation accuracy.

4.2.5 Experience in Technical Team

Experience of the technical staff plays a significant role in enhancing efficiency of operations on the functions. The study therefore sought to determine the years of experience of the technical team as presented on Table 4.3.

Table 4.3: Experience in Technical Team

	N	Min	Max	Mean	Std. Deviation
How Long Have you worked	106	2.00	18.00	9.3302	4.33309

Source: Survey Data (2017)

On the minimum, the least experienced technical personnel had worked for 2 years in their present company while on the highest experienced staff had worked in the present company for 4 years and 4 months. On average the staff had worked in their present companies for 9 years and 4 months. O'Higgins (2001) is of the view that years worked by an individual is positively correlated with experience hence from the study it could be deduced that majority of the individuals had worked for many years as indicated by a mean of 9.3302 with the maximum being 18 years and only few individuals had worked for 2 years.

4.3 Manpower Planning on Preventive Maintenance

The study sought to determine the effect of manpower planning on preventive maintenance in grain milling companies in Nakuru County, Kenya. The first aspect of operations planning in maintenance was on manpower planning. The responses on manpower planning practices in grain milling companies is presented in

Table 4.4: Manpower Planning in Preventive Maintenance

	Mean	Std. Deviation
The company prepares forecasted manpower plans based on the maintenance schedules	2.54	1.071
The company has recruited enough staff in equipment maintenance department	2.56	1.468
Staff in maintenance department have the necessary skills for the job	3.49	1.062
Staff in maintenance are recruited on merit of education qualifications	3.30	1.281
Maintenance staff are well experienced on the job	3.68	.911
The company provides adequate on the job skills training for its staff	2.08	.992
The company organizes for specialized trainings for the maintenance crew	2.23	.998
The maintenance staff are provided with all the essential tools for maintenance activities	2.24	.991
There is adequate technical support from equipment manufacturers on maintenance	2.19	.874
The maintenance crew is well motivated to perform their duties	1.77	.666

Source: Survey Data (2017)

According to the findings in Table 4.4 on manpower planning in preventive maintenance the findings revealed Maintenance staff are well experienced on the job as indicated by a mean of 3.68 and a standard deviation of 0.911 which implied the variations were not widely dispersed. The higher score of the level of experience compared to education shows that experience was considered as a more critical aspect in maintenance staffing compared to education. This study resonates well with the work of Samoff and Carrol (2003) who indicates that education was initially meant to develop skills but this is changing where emphasis is put in gaining the necessary knowledge for manpower to translate its output into tangible investment that can be counted as profit.

Regarding the skills of the maintenance teams, it was indicated that the staff in the maintenance department have the necessary skills for the job indicated by a mean of 3.49 and a standard deviation of 1.062 which implied that variations of the responses were 1 point dispersed away indicating a slight variability. The findings imply that the current staff in maintenance departments to a large extent have relevant skills to perform their jobs. According to CIPD (2010) having right people with the right skills ensures short and long term organizational objectives are met.

Majority of the staff were in disagreement that their companies prepared forecasted manpower plans based on the preventive maintenance schedules (Mean 2.54). This shows that the practice of manpower planning based on preventive maintenance schedules was less practiced in majority of the grain milling companies in Nakuru County, Kenya. According to Subramaniam, Husin, Yusop and Hamidon (2008) manpower utilization and machine efficiency contribute to production line efficiency. When machines are not maintained properly, they result into increased maintenance costs and low standards of production (Konopka & Trybula, 1996).

Concerning whether grain milling companies have recruited enough staff in equipment preventive maintenance department, majority of the staff were in disagreement as indicated by the moderate mean of 2.56 and a standard deviation of 1.468. This implies that majority of the milling companies were understaffed in the maintenance departments. Mjema (2002) while looking at personnel capacity requirements in maintenance department argues that there is need to have a consideration on the work load profile of a particular company to prevalent understaffing.

Regarding the criteria used in staff recruitment, the study indicated with a high mean of 3.30 and a standard deviation of 1.281, the staff in maintenance department are recruited on merit of education qualifications. This shows though to a large extent education was considered in recruitment of maintenance staff but in some instances, education was not considered as key. The study conforms to Leung (2004) arguments that there is need for desired technical capacity which enhances success. Without the necessary competencies, coordination between parties or work force is usually hampered leading to various work place delays.

The extent to which grain milling companies invested in providing training to its maintenance crew was also assessed and found out that majority of the companies (Mean 2.23) had little investment in staff training for their maintenance teams. The standard deviation was 0.998 which indicated a fairly low dispersal of the variables. The situation on training was even dire in the provision of specialized trainings for the maintenance crew where a great majority of the staff (mean 2.23) cited that their company did not provide specialized training for its maintenance crew. This shows that grain milling companies had very little investments on training of its maintenance crew for better performance.

Maintenance support from equipment manufacturers was also not good in grain milling companies as indicated by a low mean of 2.19 and a standard deviation of 0.874 which indicated the level of dispersal was low. Ngugi (2012) in his study on

Geothermal drilling in Kenya shows the importance of having strong technical team towards the success of ventures yet the findings of the study indicate that grain milling companies do not have the necessary maintenance support.

Motivation of the maintenance crew was poorly rated. With a very negligible mean of 1.77 and a standard deviation of 0.666 it was noted that the respondents disagreed on the assertion that the maintenance crew is well motivated to perform their duties. This shows that grain milling companies hardly planned for motivation of the maintenance crew as opposed to other staff. Different scholars have written on the importance of motivation of their employees (Manzoor, 2012; Ramlall, 2004) however the findings of this study show that the maintenance crew is not properly motivated. This implies that their productivity will be low.

4.4 Spares Availability on Preventive Maintenance

The second objective for the study was to assess the effect of spares availability on preventive maintenance in Grain Milling Companies in Nakuru County. To achieve this study, the study sought to assess the spares availability situation in the various grain milling companies which was later analyzed against the performance of preventive maintenance in the mills. The findings are discussed in Table 4.5.

Table 4.4: Spare Part Availability

	Mean	Std. Deviation
The maintenance team prepares plans on the expected spares for use in preventive maintenance	2.24	1.231
There is an inventory of spares maintained in the company for preventive maintenance	2.25	1.233
Allocation of spares for preventive maintenance is done differently from those for corrective maintenance	1.49	.621
Allocation of spare parts to work orders is done smoothly	1.92	.818
The procurement team avails spares for equipment maintenance on time	1.74	.876
The quality of spares availed by the procurement team is good enough compared to original parts	2.51	1.205
Reliance on imported spares does not affect equipment down time	1.70	.733
There is little time incurred in obtaining spares from the warehouses	1.92	.789
There are no bureaucracies in the approval of spares for use in equipment maintenance	1.60	.686
Organization of the spares warehouse makes it easy to locate spares when needed	3.46	1.097
The company has efficient system of monitoring and controlling the spares inventory	3.75	.892
The spares management personnel have adequate technical skills	4.45	.571
There is 24 hour access to the spares warehouse	4.07	.887

Source: Survey Data (2017)

The findings on spares availability in preventive maintenance shown in Table 4.5 revealed that he spares management personnel have adequate technical skills as indicated by a mean of 4.45 which was considered big enough as it had its indications towards 'strongly agreeing'. Its standard deviation was 0.571 which showed the variables were not widely dispersed.

It was also established that there was a 24-hour spare part accessibility (mean 4.07). This imply that spare parts can be accessed throughout the shifts hence production mostly should not be hampered as a result of lack of spare part. The study resonates well with Kumar and Knezevic (1998) who indicate that through use of a prediction of the required number of spare parts for a system to achieve specified inherent availability can be done. The findings further disagreed on the assertion that there is little time incurred in obtaining spares from the warehouse as presented by a mean of 1.92 and a standard deviation of 0.789. This implies that available time for obtaining spare parts from the warehouse is usually adequate.

On the monitoring of spares inventory, a great majority (Mean 3.75) were of the view that their companies had efficient systems of monitoring and controlling the spares inventory. This implies that control measures are usually undertaken if need be by the organization when it came to spare part availability. Rausch and Liao (2010) in their study, monitor reduction in performance of a critical unit. Replacement action using spare part inventory control and due date constraints are initiated as a result of degradation. Which can only be done as a result of having efficient monitoring and control system.

The level of organization of the spares warehouse made it easy to locate spares when needed according to a moderate mean of 3.46 and a standard deviation of 1.097. This therefore shows that 48.1% of the millers had their spares stores efficiently organized while the rest were not.

The quality of spares was also interrogated, with a slightly smaller mean of 2.51 and a standard deviation of 1.205 which implied the variances were 1 point dispersed away indicated that the quality of the spare part availed by the procurement team was not good enough compared to original products. To this effect, Kennedy, Patterson and Fredendall (2002) articulate that any inventory in spare part is not a final product to be sold to customers. It is to this effect that spare parts inventory policies are different from those that govern work in progress (WIP) and other inventories.

Planning of the expected spares for use in preventive maintenance was rated poorly (2.24 and a standard deviation of 1.231. This implies that planning preventive maintenance spares was less practiced in grain milling companies in Nakuru County.

As to whether companies maintained inventory of spares for preventive maintenance, it was established that there was a relatively low mean of 2.25 and a standard deviation of 1.233. This implies that there were no spares inventories for preventive maintenance. In addition, a great majority (mean 1.92) disagreed that the allocation of spare parts to work orders was done smoothly. This implies that majority of the grain milling companies in Nakuru County experienced challenges of maintenance and issuance of spares for preventive maintenance operations. It is to this effect that Ngugi (2012) asserts that it is important for manufacturing institutions to conduct proper inventory management and planning to ensure supply of critical spare parts and materials.

Reliance on imported spares was adversely cited as a challenge in preventive maintenance as it affects the equipment down time (mean 1.70). The findings agree with the works of Al-Kharashi and Skitmore (2009) who opined that lack of strategic planning for materials and labor was a major cause of delay on delivery of spare parts.

4.5 Production Planning on Preventive Maintenance

The third objective for the study sought to determine how production planning affected preventive maintenance in Grain Milling Companies in Nakuru County. This was determined by first seeking opinion on the production parameters that had an effect on preventive maintenance in grain milling companies. The findings are presented in Table 4.6.

Table 4.5: Production Planning on Preventive Maintenance

	Mean	Std. Deviation
There are elaborate preventive maintenance schedules shared with the production team	3.42	1.041
Machine operators are charged with simple maintenance assignments	3.88	.870
Preventive maintenance schedules are developed jointly between maintenance and production team	3.32	.952
There are standby equipment to facilitate preventive maintenance without stopping operations	2.12	1.057
Machine overhauls are done in between production batches	4.09	.941
The Maintenance crew sticks to their main objective of ensuring machine availability for production	2.22	1.138
Maintenance schedules are developed considering appropriate levels of capacity	3.79	1.209
Production schedules are used in developing maintenance schedules	3.13	.957
The production team plans to avail machines for preventive maintenance	2.52	1.007

Source: Survey Data (2017)

The study established that machine overhauls are done in between production as indicated by a mean of 4.09 and a standard deviation of 0.941. This implies that dangers of machines stopping during production are minimized Cassady and Kutanoglu (2005) in their study opine that there is an interdependence between preventive maintenance planning and production scheduling. Their study indicates that integrated preventive maintenance planning, and production scheduling should be focused on critical machines.

Further, it was revealed that machine operators are charged with simple maintenance assignments (mean 3.88, standard deviation 0.870). All the millers embrace the concept of operator maintenance. Mula, Poler, Garcia-Sabater and Lario (2006) are of the opinion that uncertainty is taken as a serious issue in manufacturing system. It is due to this reason that they indicate the importance of a classification scheme which can be used for production planning under uncertainty.

Concerning whether maintenance schedules are developed with consideration of appropriate levels of machine capacities, the study indicated with a mean of 3.79 and a standard deviation of 1.209 that is the current practice in grain milling firms. Aghezzaf, Jamali and Ait-Kadi (2007) affirm this study by indicating that for capacities of machine to be considered, there is need for an integrated production and preventive maintenance system that satisfies the demands of manufacturing firms. Their solution is in planning for a system that undergoes periodical renewal and repairs are not done at machine failures.

A moderate mean of 3.42 and a standard deviation of 1.041 demonstrating 1-point scatter of the variables indicate that there were at least elaborate preventive maintenance schedules shared with the production team. This further indicate that the team on working on the companies' machines are aware of what need to be done when it comes to maintenance.

The practice of jointly planning maintenance schedules between production and maintenance team was also cited by over half of the staff (Mean 3.32). This imply that there is great consultation between the two teams. Aghezzaf and Najid (2008) look at integrated production planning and preventive maintenance. They indicate that a production line failure leads to repairs which temporarily reduces production capacity. There is therefore need for cyclic preventive maintenance to prevent reduced production in manufacturing firms. This situation calls for planning to ensure performance and production are maintained. This can only be done when there is close coordination between the two teams.

It was noted that the production team does not usually plan to avail machines for preventive maintenance (Mean 2.52, standard deviation 1.007). This shows that the production teams in most milling companies were not keen in ensuring preventive maintenance was done on their machines. It also shows lack of synergy between production planning and maintenance planning in implementing preventive maintenance. The findings of this study resonates well with previous studies. Budai, Dekker and Nicolai (2006) are of the opinion that maintenance is related to production in several ways. Further the cost of lost production should be keenly looked at as through use of preventative maintenance as indicated by Cai and Hasenbein (2011).

Lastly, it was prudent to ascertain whether the maintenance crew stick to their main objective of ensuring machine availability for production. The study indicates with a very low mean of 2.22 that the practice was not adhered to by the maintenance crew. This shows lack of proper collaboration in achieving the productivity objective. Budai, Dekker and Nicolai (2006) relates maintenance to production thus they argue that since maintenance jobs takes production capacity away there in need to plan together the two elements thus alluding to this study on the importance of proper collaboration in achieving productivity goals.

4.6 Plant Layout on Preventive Maintenance

The fourth objective of the study sought to analyze the effects of plant layout on preventive maintenance in Grain Milling Companies in Nakuru County. Opinion of the technical staff regarding plant layout in their firms and how it affected the preventive maintenance activities was sought and presented in Table 4.7 and discussed thereafter.

Table 4.6: Plant Layout on Preventive Maintenance

	Mean	Std. Deviation
The layout of equipment enables easy access to machine parts for maintenance	3.71	.647
Machine layout is done in a way that ensures minimum interruption in production when performing preventive maintenance	3.85	.860
There are provisions for by passing certain units in production to allow maintenance of others	3.58	.975
There are alternative production line that are used for emergency production during maintenance	2.34	1.257
The machine layout ensures that there is no interference with the utilities during maintenance	4.03	.827
The plant layout designs are available to guide maintenance technicians	3.24	1.185
The equipment layout enables smooth flow of work during preventive maintenance	3.96	.791

Source: Survey Data (2017)

On the layout of machines and utilities, it was noted that there is no interference with the utilities during maintenance as indicated by a mean of 4.03 and a standard deviation of 0.827. This imply that maintenance is usually done keenly not to interfere with any companies' utility. The study also sought to determine whether equipment layout enabled smooth flow of work during preventive maintenance. It was indicated with a mean of 3.96 which pointed towards 'agreeing' that meant equipment layout enabled the smooth flow of work during preventive maintenance. Gupta and Seifoddini (1990) indicate that most companies in the US have realized the importance of having a layout that enables smooth flow of work thus they reorganize their plant layout every two years.

The study established that the Machine layout is done in a way that ensures minimum interruption in production when performing preventive maintenance as depicted by a mean of 3.85 and a standard deviation of 0.860. This shows that machine layout was highly considerate of maintenance activities. The findings in Table 4.7 revealed that majority of the technical staff were in agreement that the layout of equipment enabled easy access to machine parts for maintenance (mean 3.71, Standard deviation 0.647. This shows that machine layout was a critical factor in ensuring efficient preventive maintenance.

A good majority of the staff were also in agreement that there were provisions for by passing certain units in production to allow maintenance of others. (Mean 3.58, standard deviation 0.975). Bypass would allow some equipment to be skipped during production therefore availing them for maintenance without interrupting the production.

Regarding the availability of plant layout designs, it was noted that on a moderate mean (3.24) that there were available guide maintenance technicians. This imply that incase of machine breakdown, the technicians aid in the layout process.

It was noted that there were no alternative production lines that are used for emergency production during maintenance as indicated by a relatively low mean of 2.34 and a standard deviation of 1.257. This imply that planning for maintenance should be done when the company has enough stock to ensure that customers do not fail to have their preferred goods as a result of preventive maintenance. It is due to this reason that Cassady and Kutanoglu (2005) look at integrating preventive maintenance planning and production scheduling for a single machine. They try to show the importance of the interdependence of the two function by use of an experimental study.

4.7 Effective Preventive Maintenance

The dependent variable for the study was the effectiveness of preventive maintenance in grain milling companies in Nakuru County. This was assessed on a five point likert scale whose scores are shown on Table 4.8.

Table 4.7: Effective Preventive Maintenance

	Mean	Std. Deviation
The company has elaborate preventive maintenance schedules in place	3.08	.836
There is strict adherence to preventive maintenance schedules by crew	2.51	.784
Maintenance schedules are done based on manufacturers specifications	2.31	.979
The maintenance schedules are comprehensive in coverage	2.62	1.099
There are standby equipment to facilitate preventive maintenance without stopping operations	2.74	.929
There are systems installed to monitor machine conditions	3.69	1.166
The machine breakdowns are very minimum in the company	2.60	1.300
Machine availability is up to the recommended international standards	1.71	.601

Source: Survey Data (2017)

The study indicated that there are systems installed to monitor machine conditions as depicted by a moderately large mean of 3.69 and a standard deviation of 1.166. This implies that the maintenance departments to a large extent used systems for monitoring machine conditions for purposes of preventive maintenance. Presence of a monitoring system further indicate effective planning in the grain milling companies.

The slight higher mean of 3.08 and a standard deviation of 0.836 indicate that at least the company has elaborate preventive maintenance schedule in place. This however had mixed reactions as 56% were not decided on whether the company had such a plan or not. This implies that preventive maintenance policies were not very effective. Ngugi (2012) supports the findings of the study by indicating that it is important for management to conduct proper inventory management and planning to ensure continuous supply of critical spares and materials. Further, Al-Kharashi and Skitmore (2009) identified a lack of strategic planning for materials and labor as a major cause of delays on delivery which prevents effective preventive maintenance.

On the presence of standby equipment to enable preventive maintenance operations without stopping operations, it was revealed that there were no standby equipment as indicated by a mean of 2.74. This implies that a larger proportion of milling companies did not have standby equipment that could allow concurrent preventive maintenance.

Regarding whether maintenance schedules were comprehensive enough, the study established that they were not (mean 2.62, standard deviation of 1.099). This shows that the technical staff were not convinced that preventive maintenance schedules were comprehensive enough. Canfield (1986) realized the importance of periodic maintenance thus developed a periodic maintenance model that could be used for optimizing average cost rate.

The eventual outcome of preventive maintenance in terms of frequency of machine breakdowns was also assessed. The findings revealed that half of the respondents were of the opinion that machine breakdowns are not minimal as depicted by a mean of 2.60. This shows the level of machine breakdowns were high in majority of the milling plants.

It was further noted that adherence to preventive maintenance schedules were not strict as indicated by a small mean of (2.51). The standard deviation was 0.784 which meant the variations were not very scattered. This finding conforms to Koushki and Kartam (2004) who opine that late delivery of materials cause delays hence this becomes a challenge towards adherence to set schedules.

The study revealed that the maintenance schedule was not done based on manufactures specifications (mean of 2.31 and a standard deviation of 0.979). This implies that there is a danger of not following the given guidelines as the machines might break up due to not following up manufacturing specifications. This means that the level of adherence to manufacturer's preventive maintenance guidelines was low in grain milling companies. The study agrees with previous studies that stated machine breakdowns are very high and thus they tried to come up with ways of minimizing the breakdowns. Gupta (1981) formulated a maintenance scheduling problem under practical constraints. Nakagawa (1981) derived mean time between maintenance formulas for periodic preventive maintenance. Canfield (1986) developed a periodic maintenance model for optimizing average cost rate. Chen (2006) addressed the resumable and non-resumable cases for the single machine and parallel machine scheduling problems. Batun and Azizoğlu (2009) proposed a branch and bound algorithm to study the single machine total flow time problem in which the jobs are non-resumable and the machine is subject to PM activities of known starting times and durations. While Ruiz et al. (2007) proposed tools in the form of adaptation of heuristic and meta-heuristic methods to implicitly consider PM operations in permutation flow shop sequencing problems. All these were efforts on reducing the breakdown of machines and increasing effective preventive maintenance efforts.

4.8 Correlation Analysis

A correlation analysis was thus undertaken to check whether there was a relationship and the strength of the relationship between the independent and dependent variable. A presentation of the correlation matrix is presented in Table 4.9 as follows:

Table 4.9: Correlation Matrix

		manpower planning	spares part availability	Production planning.	plant layout
manpower planning	Pearson Correlation	.726**	.454**	.691**	.686**
	Sig. (2-tailed)		.000	.000	.000
	N	106	106	106	106
Spares part availability	Pearson Correlation	454**	1	-.720**	-.766**
	Sig. (2-tailed)	.000		.000	.000
	N	106	106	106	106
production planning	Pearson Correlation	.691**	-.720**	1	.784**
	Sig. (2-tailed)	.000	.000		.000
	N	106	106	106	106
plant layout	Pearson Correlation	.686**	-.766**	.784**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	106	106	106	106

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

Source: Survey Data (2017)

On manpower planning towards preventive maintenance, a correlation analysis was used to check the relationship between the two variables. The results of the study indicate that r= .726 indicating a positive strong correlation between manpower planning and preventive maintenance. Further the relationship was significant at p=

$0.00 < \alpha$ (0.05). The implication deduced is that planning for manpower has an influence on preventive maintenance. As planning for manpower increases so does preventive maintenance. The null hypotheses stating manpower planning has no effect on preventive maintenance in Grain Milling Companies in Nakuru County was tested. The P value (0.00) being less than the alpha value of (0.05) led to the hypotheses to be rejected and conclusions were drawn that manpower planning has an effect on preventive maintenance in grain milling companies in Nakuru County.

On the effects of spare part availability on preventive maintenance, it was established that r= .454 indicating a positive moderate correlation between spare part availability and preventive maintenance. The relationship is further significant at $p=0.00 < \alpha$ (0.05). The hypothesis was tested and since the p value was less than the alpha value, it led to a rejection in the hypotheses and the alternative hypotheses was adapted indicating that spares part availability does have an affect preventive maintenance.

There is a moderate strong positive relationship between production planning and preventive maintenance with r= .691 which was significant at $p= 0.00 < \alpha$ (0.05). Planning for production means that there will be an increase in preventive maintenance. The null hypothesis was tested, since the P value was less than the alpha value. The null hypothesis was rejected and the alternative one adapted indicating production planning has an influence on preventive maintenance.

Lastly on effects of plant layout on preventive maintenance, the study established that r= .686 which is a moderate positive relationship. The findings revealed there was a correlation between plant layout and preventive maintenance. Further the relationship was significant at $p=.000 < \alpha$ (0.05). The null hypothesis was tested and it was rejected since the p value was less than the α. An alternative hypothesis was thus adapted stating plant layout does not affect preventive maintenance in Grain Milling Companies in Nakuru County.

Table 4: 10 Summary of Hypotheses Test

Hypothesis	Accepted α Values	Computed p-values for variables	Conclusion
H_0: $\mu_1 = \mu_2$ $\mu_1 - \mu_2 = 0$ manpower planning has no effect on preventive maintenance in Grain Milling Companies in Nakuru County	α = 0.05	0.00	Null hypothesis rejected
H0: μ1 = μ2 μ1 - μ2 = 0 Spares part availability does not affect preventive maintenance in Grain Milling Companies in Nakuru County	α = 0.05	0.00	Null hypothesis rejected
H_0: $\mu_1 = \mu_2$ $\mu_1 - \mu_2 = 0$ Production planning has no influence on preventive maintenance in Grain Milling Companies in Nakuru County.	α = 0.05	0.05	Null hypothesis rejected
H_0: $\mu_1 = \mu_2$ $\mu_1 - \mu_2 = 0$ Plant layout does not affect preventive maintenance in Grain Milling Companies in Nakuru County.	α = 0.05	0.05	Null hypothesis rejected

Source: Survey Data (2017)

4.9 Regression Analysis

To analyze the relationship between operations maintenance planning and the preventive maintenance the study used multiple regression analysis. The general purpose of multiple regressions is to learn more about the relationship between several independent or predictor variables and a dependent or criterion variable. It is used to make predictions on criterion variable based on changes in the predictor variables. In this study, average scores for all the four variables on preventive maintenance applied by Grain Milling companies were subjected to multiple regression analysis against the average score on effectiveness of maintenance practice. The results of regression analysis are presented on Table 4.9,10 & 11.

Table 4.8: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.639[a]	.408	.397	.39764

a. Predictors: (Constant), Plant layout, Production planning, spares parts planning, man power planning

Source: Research Data (2017)

The coefficient of determination (R^2) explains the extent to which changes in the dependent variable can be explained by the change in the independent variables or the percentage of variation in the dependent variable (preventive maintenance) that is explained by all four independent variables (plant layout, spares availability, production planning, manpower planning). The adjusted R-squared shows the explanatory power of regression model which implies the model has an explanatory power of 39.7%. The regression model summary on in Table 4.10 a shows an R^2= 0.408 which implied that the four independent variables of the study accounted for 40.8% of the variations in preventive maintenance observed.

Table 4. 9: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.817	4	.954	6.035	.000[a]
	Residual	15.970	101	.158		
	Total	19.787	105			

a. Predictors: (Constant), Plant layout, Production planning, spare parts planning, manpower planning

b. Dependent Variable: Preventive maintenance

Source: Survey Data (2017)

ANOVA tests on Table 4.10, were used to test the model significance in explaining the relationship. The results ($F_{(4,101)} = 6.035$, $\rho < 0.05$) shows that the model significantly explains the relationships under investigation. Regression coefficients and the results as shown on the Table 4.11

Table 4.10: Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.723	.566		6.578	.000
	Man power planning	.528	.156	.402	3.389	.001
	Spare parts planning	.690	.200	.358	3.441	.001
	Production planning	.329	.094	.367	3.520	.001
	Plant layout	.293	.166	.219	2.770	.040

a. Dependent Variable: Preventive maintenance

Source: Survey Data (2017)

The beta coefficients on Table 4.10 shows that holding all other factors constant at zero, a unit increment in manpower planning would result to 0.528 times improvement in efficiency of preventive maintenance in graining milling companies. On the other hand, holding all other factors constant at zero, a unit increment in the spare parts planning would result in 0.690 improvements in efficiency of preventive maintenance. The regression results also imply that while holding other factors constant at zero, a unit improvement in production planning would result into 0.329 times improvement in preventive maintenance efficiency. Lastly, a unit improvement in plant layout would result into 0.293 times improvement in efficiency of preventive maintenance. This infers that all the four factors under investigation have a significant impact on performance of preventive maintenance. However, spare part planning and manpower planning were found to have higher contribution.

The relationship between variables can therefore be represented in the following regression model:

$Y = 3.723 + 0.528\ X_1 + 0.690X_2 + 0.329X_3 + 0.294\ X_4 + \varepsilon$

Therefore, Preventive Maintenance = 3.723 + 0.528 Manpower planning +0.690 Spares planning + 0.329 production planning + 0.294 plant layout.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMEDATION

5.1 Introduction

The chapter presents a summary of the findings for the study, conclusions and recommendations. Recommendations for further research are also suggested.

5.2 Summary of Findings

The first objective of the study was to establish the effect of manpower planning on preventive maintenance in Grain Milling Companies in Nakuru County. The findings revealed that: Majority of the companies did not prepare forecasted manpower plans based on the preventive maintenance schedules. Besides majority of the milling companies were understaffed in the maintenance departments although the current staff in maintenance departments to a large extent had the relevant skills to perform their jobs. Education level was taken into consideration in recruitment of maintenance staff but in some instances, education was not considered as key. Motivation of the maintenance crew was poorly rated. Regression results however revealed that manpower planning played a significant role in ensuring efficiency in preventive maintenance in milling companies.

The second objective for the study was to assess the effect of spares availability on preventive maintenance in Grain Milling Companies. The findings revealed that; the planning of the expected spares for use in preventive maintenance was rated poorly which implies that planning preventive maintenance spares was less practiced in grain milling companies. Allocation of spares for preventive maintenance was not done differently from those for corrective maintenance. It was also revealed that majority of the grain milling companies in Nakuru County experienced challenges of maintenance and issuance of spares for preventive maintenance operations. Majority of the companies experienced challenges of timely acquisition of spares for preventive maintenance as well as quality of spares. Reliance on imported spares was adversely cited as a challenge in preventive maintenance. Even within the company premises, the lead time in getting spares to the shop floor was still high. The level of organization of the spares warehouse in most companies made it easy to locate spares when needed.

The third objective sought to determine how production planning affects preventive maintenance in Grain Milling Companies. In majority of the milling companies the concept of operator maintenance was embraced. The practice of jointly planning maintenance schedules between production and maintenance team was also cited by over half of the staff. However, majority of the companies did not have standby equipment in place to facilitate preventive maintenance without stopping operations. The maintenance crew was rated poorly in ensuring machine availability for production. It was also observed that the production team in most milling companies was not keen on ensuring preventive maintenance was done on their machines. The above findings indicate lack of synergy between production planning and maintenance planning teams in implementing preventive maintenance in milling companies although production planning had a significant positive impact on the effectiveness of preventive maintenance.

The fourth objective sought to analyze the effects of plant layout on preventive maintenance in Grain Milling Companies. The findings revealed that majority of the technical staff were in agreement that the layout of equipment enabled easy access to machine parts for maintenance. In majority of the companies that were under study, machine layout was done in a way that ensured minimum interruption in production when performing preventive maintenance. Furthermore, the staffs were also in agreement that there were provisions for by-passing certain units in production to allow maintenance of others. However, in majority of the plants there were no alternative production lines that were used for emergency production during maintenance. On the layout of machines and utilities it was also evident that in majority of the plants the machine layout ensured that there were no interference with the utilities during maintenance. A good proportion of the mills however did not have proper equipment layout designs to guide in planning and implementation of preventive maintenance activities. Plant layout too was found to have a significant effect on efficiency of preventive maintenance.

5.3 Conclusion

The study concluded that manpower planning played a significant role in ensuring effectiveness in preventive maintenance. However, it was not given proper attention in majority of the milling companies.

Spares availability played a significant role in ensuring efficiency of preventive maintenance in grain milling companies. However, the availability of spares still presented challenge to preventive maintenance in grain milling companies in Nakuru County owing to their lack of ready availability, and delays in acquisition.

Production planning had a significant effect on preventive maintenance in grain milling companies in Nakuru County. The joint maintenance planning enabled consideration of production schedules as well as maintenance schedules in developing efficient operation schedules. However, in some companies the production teams focused more on production and gave less attention to equipment maintenance especially preventive maintenance.

The plant and equipment layout in grain milling companies has a significant effect on the efficiency of performing preventive maintenance. However, in some of the milling companies in Nakuru County, equipment layout designs were not well elaborate or were missing.

5.4 Recommendation

The grain milling companies need to prepare focused plans that can be used for preventive maintenance schedules. These plans will enable manpower planning in the different departments of preventive maintenance which eventually will solve the problem of understaffing. Further, these plans will enable the organization plan on how to motivate their maintenance crew leading to better performance.

Spare parts should be availed at the needed time. This can be done through having timely requisition that will enable their availability. Unga feeds should work towards updating their spare part inventory. The store keeper needs to have an updated record each time spare parts are released to enable the company restock with ease.

There is need for Unga limited to source for standby equipment's that will enable facilitation of preventive maintenance. The production and maintenance crew should constantly undergo refreshers courses to make them embrace modern techniques for preventive maintenance. Additionally, top level management should try and foster team work and put emphasis on importance of synergy between production planning and preventive maintenance.

Unga limited should come up with an alternative production line for emergency manufacturing during maintenance phase. The layout should be set in such a way that there would be no interference with the utilities during maintenance. Proper equipment designs that can be used for guiding planning and implementation of preventive maintenance should be put in place.

5.5 Recommendation for Further Research

The study recommends further comparative research to be done to understand how companies come up with priority strategies for preventive maintenance. This study should also be performed in milling companies in other regions to enhance the generalizability of the study to all grain milling companies in Kenya.

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APPENDICES

Appendix 1: Introduction Letter

Haron Angaluki

P.O. Box, 106-30100,

ELDORET.

Email: angalukih@gmail.com

Phone: 0725028818

3rd August, 2016.

RE: FILLING OF QUESTIONNAIRES

I am a student at Kenyatta University, Nakuru Campus. I would wish to request you to provide me with the information as asked by this questionnaire to facilitate in the completion of an academic research titled:

Operations Management Planning and Preventive Maintenance in Grain Milling Companies in Nakuru County, Kenya

Any clarifications or additional information required can be obtained from the University or through the contact address provided.

Your assistance will be highly appreciated.

Thank you in advance.

Yours Faithfully

Haron Angaluki

Appendix 2: Research Questionnaire

Section A: General Information

1. Name (optional) ……………………………………………………………………….

2. Indicate your gender.

Male [ ] Female [ ]

3. What is your Age? ………………………………. Years

4. Indicate your designation

Maintenance engineer [ ] Technician [ ] Fitter [ ]

Production Manager [ ] Production Supervisor [ ]

Procurement Officer [ ] Stores Clerk [ ]

5. Kindly indicate your highest academic qualification

Certificate [ ] Diploma [ ]

Bachelor Degree [ ] Master Degree [ ]

Any other (please specify) [ ]

6. For how long have you worked with this company?................... Years

Section B: Manpower Planning

What is your opinion on the following statements on manpower planning in maintenance in your company? Indicate your opinions as 1 – Strongly disagree, 2 – Disagree, 3 – Neither agree nor Disagree, 4 – Agree, 5 – Strongly Agree

	1	2	3	4	5
7. The company prepares forecasted manpower plans based on the maintenance schedules					
8. The company has recruited enough staff in equipment maintenance department					
9. Staff in maintenance department have the necessary skills for the job					
10. Staff in maintenance are recruited on merit of education qualifications					
11. Maintenance staff are well experienced on the job					
12. The company provides adequate on the job skills training for its staff					
13. The company organizes for specialized trainings for the maintenance crew					
14. The maintenance staff are provided with all the essential tools for maintenance activities					
15. There is adequate technical support from equipment manufacturers on maintenance					
16. The maintenance crew is well motivated to perform their duties					

17. In your own opinion how would you rate the manpower planning practices in the maintenance department in your company?

____

____

____

Section C: Spares Parts planning

What is your opinion on the following statements on spare parts planning in equipment maintenance in your company? Indicate your opinions as 1 – Strongly disagree, 2 – Disagree, 3 – Neither agree nor Disagree, 4 – Agree, 5 – Strongly Agree

	1	2	3	4	5
18. The maintenance team prepares plans on the expected spares for use in preventive maintenance					
19. There is an inventory of spares maintained in the company for preventive maintenance					
20. Allocation of spares for preventive maintenance is done different from those for corrective maintenance					
21. Allocation of spare parts to work orders is done smoothly					
22. The procurement team avails spares for equipment maintenance on time					
23. The quality of spares availed by the procurement team is good enough compared to original parts					
24. Reliance on imported spares does not					

affect equipment down time					
25. There is little time incurred in obtaining spares from the warehouses					
26. There are no bureaucracies in the approval of spares for use in equipment maintenance					
27. Organization of the spares warehouse makes it easy to locate spares when needed					
28. The company has efficient system of monitoring and controlling the spares inventory					
29. The spares management personnel have adequate technical skills					
30. There is 24 hour access to the spares warehouse					

31. What is your own opinion on the spares planning for use in preventive maintenance in your company?

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____

Section D: Production Planning

What is your view on Production Planning in relation to preventive maintenance in your company? Indicate your opinions as 1 – Strongly disagree, 2 – Disagree, 3 – Neither agree nor Disagree, 4 – Agree, 5 – Strongly Agree

	1	2	3	4	5
32. There are elaborate preventive maintenance schedules shared with the production team					
33. Machine operators are charged with simple maintenance assignments					
34. Preventive maintenance schedules are developed jointly between maintenance and production team					
35. There are standby equipment to facilitate preventive maintenance without stopping operations					
36. Machine overhauls are done in between production batches					
37. The Maintenance crew sticks to their main objective of ensuring machine availability for production					
38. Maintenance schedules are developed considering appropriate levels of capacity					
39. Production schedules are used in developing maintenance schedules					
40. The production team plans to avail machines for preventive maintenance					

41. In your own view how does production schedule affect implementation of preventive maintenance in your company?

SECTION E: Plant layout

What is your view on the plant equipment layout in your company in relation to Preventive maintenance? Indicate your opinions as 1 – Strongly disagree, 2 – Disagree, 3 – Neither agree nor Disagree, 4 – Agree, 5 – Strongly Agree

	1	2	3	4	5
42. The layout of equipment enables easy access to machine parts for maintenance					
43. Machine layout is done in a way that ensures minimum interruption in production when performing preventive maintenance					
44. There are provisions for by passing certain units in production to allow maintenance of others					
45. There are alternative production line that are used for emergency production during maintenance					
46. The machine layout ensures that there is no interference with the utilities during maintenance					

47. The plant layout designs are available to guide maintenance technicians					
48. The equipment layout enables smooth flow of work during preventive maintenance					

49. In your view how does machine layout affect preventive maintenance in your company?

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Section F: Preventive Maintenance performance

How would you rate your company on its performance in preventive maintenance? Use the scale: 1 – Strongly disagree, 2 – Disagree, 3 – Neither agree nor Disagree, 4 – Agree, 5 – Strongly Agree

	1	2	3	4	5
50. The company has elaborate preventive maintenance schedules in place					
51. There is strict adherence to preventive maintenance schedules by crew					
52. Maintenance schedules are done based on manufacturers specifications					
53. The maintenance schedules are comprehensive in coverage					
54. There are standby equipment to facilitate					

preventive maintenance without stopping operations					
55. There are systems installed to monitor machine conditions					
56. The machine breakdowns are very minimum in the company					
57. Machine availability is up to the recommended international standards					

58. How would you describe your company in the implementation of preventive maintenance?

____

____

Thank you

Appendix 3: Research Authorization

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone:+254-20-2213471, 2241349,3310571,2219420
Fax:+254-20-318245,318249
Email:dg@nacosti.go.ke
Website: www.nacosti.go.ke
when replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/17/20284/15468**

Date: **15th March, 2017**

Haron Agoi Angaluki
Kenyatta University
P.O. Box 43844-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on **"*Operations management planning and preventive maintenance in grain milling companies in Nakuru County, Kenya,*"** I am pleased to inform you that you have been authorized to undertake research in **Nakuru County** for the period ending **15th March, 2018.**

You are advised to report to **the County Commissioner and the County Director of Education, Nakuru County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Nakuru County.

The County Director of Education
Nakuru County.