CHAPTER ONE MAINTENANCE PRACTICES FOR EFFECTIVE FOUNDRY PRACTICE IN MINNA METROPOLIS OF NIGER STATE

BY

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2016/1/59102TI

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MARCH, 2023.

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A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION, SCHOOL OF TECHNOLOGY EDUCATION, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF TECHNOLOGY (B. TECH) DEGREE IN INDUSTRIAL AND TECHNOLOGY EDUCATION.

MARCH, 2023.

DECLARATION

I **Adegbenga Opeyemi Olaitan**, with matriculation number **2016/1/59102TI**, an undergraduate student of the department of Industrial and Technology Education, certify that the work embodied in this project is original and has not been submitted in part or full for any other diploma or degree of this or any other University.

Adegbenga Opeyemi Olaitan, ...
2016/1/59102TI

....
Sign and Date

CERTIFICATION

This project has been read and approved as meeting the requirement for the award of B. Tech degree in Industrial and Technology Education, School of Technology Education, Federal University of Technology, Minna.

Prof. I.Y Umar

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Project Supervisor Signature and Date

Dr, T.M SABA

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Head of Department Signature and Date

__________________ __________________

External Examiner Signature and Date

DEDICATION

With profound joy and gratitude in my heart, I dedicate this project to God Almighty for His Unshakable and Unbreakable Faithfulness. His Divine and constant guidance in my life has made this project a reality today. Thank God.

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I wish to express my sincere gratitude to Almighty God under whose care and guidance my existence. I glorify Him for leading me through yet another phase of my educational career.

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ABSTRACT

This study examined the maintenance practices for effective foundry practice in Minna Metropolis of Niger State. Three research questions were developed to guide the study and three null hypotheses were tested at 0.05 level of significance. The study employed a survey research design. The study used a four-point scale questionnaire, which contains a total of 25-items, as instrument. The total population of the study is 80 respondents comprising 60 metalworkers and 20 metalwork teachers. The result showed Poor response to maintenance needs, Lack of proper preventive maintenance, Lack of proper personnel training to maintain foundry machine, Poor work environment, Poor maintenance record keeping. The study recommended among other things, The administrators should utilize the findings of this study on the technical skills required in foundry technology as the areas their teachers needs improvement to approve requests from their teachers for sponsorship to participate in re-training programme to equip them effectively for teaching foundry technology to the students in their colleges.

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INTRODUCTION

1.1 Background to the Study

Casting is the first and a major division of Foundry Technology. Both casting and foundry technology employ the use of metal in its molten state, thus the relationship. Khan (2005) explained that foundry technology is that aspect of metalwork technology that deals with casting and foundling of metal. Rosenthal (2000) stated that foundry or casting is a process of forming metal objects by melting and pouring into molds. In other words, foundry is an aspect of metalwork that involves melting and pouring molten metal into mold to form metal objects. Panchal (2010) stated that, world economy rested on the stability of foundry and steel industries and confirmed that, the foundry Industry is major feeder to the major industrial sectors that drive technological growth.

Casting is very important for the technological growth of any country. Apart from providing employment for its citizens, especially the youth, it is a major means of producing metal objects. More importantly, it is sometimes the only means known to man for producing objects with complex intricate shapes. Panchal, (2010) observed that, foundry technology is very important to technological development of a nation, as 65% of the automobile and industrial parts and spares are produced through casting, while forming and fabrication takes 25%; other processes 10% percent. Nigeria Steel Development Authority (2009) added that, even where other means of production exist, casting may still be the cheapest and easiest means.

Metal casting involves intricate and complex production techniques and processes. These techniques include sand casting, precision casting, die casting, investment casting, centrifugal casting and shell mold casting among others (Rafi, 2004; Crewfaned, 1972). Among these techniques, sand casting is the most prominent and adoptive. This is because the materials needed for most of its operations and processes are locally available. Consequently, opportunities avail for Polytechnic graduates who will want to engage in self- employment to reach out to sand casting. The casting process, often called foundling is a clustered skill trade, which involves numerous sequential processes which ranges from pattern making, core and mold making for intricate shapes, heating or melting, pouring and fettling (George, 1999).

By the nature of creation there is virtually nothing man-made that is indestructible, but the usefulness of many such items can be extended by carrying out repair at regular intervals through an activity known as maintenance. White (1979) defined maintenance as the "work undertaken to restore every facility to an acceptable standard at an acceptable cost". The use and exposure to environmental conditions subjects machines, buildings and other service facilities to deterioration. The process of deterioration if unchecked, culminate in rendering these facilities unserviceable and brings them to a standstill. Firms and organization, therefore has no choice but to attend to them from time to time, to repair and recondition them so as to prolong their usefulness to the extent, they are economically and physically possible to do so.

Maintenance is also defined in British Standard (B.S) 3811 1984 as the combination of all technical and associated administrative action intended to retain an item in or restore it to a state in which it can perform its required function. To retain, implies that defect are allowed to occur before they are corrected (Bamisile, 2004) the objective of all the type of maintenance is to keep system going at an acceptable level. In order to keep a building in an acceptable condition, failures must be precluded, this implies that exhibit symptoms of failure have to be identified and renewed before failure occurs. This process is referred to as preventive maintenance. It depend primarily on the ability to predict the life span of all the building component, on the other hand, where failure occurs, then any work done to the building to restore it, to the initial state or an acceptable condition constitute corrective maintenance.

Maintenance is made responsible, for provision of a condition, of machines, buildings, and services that will permit uninterrupted implementation of plans requiring their use. Theoretically, maintenance should aim at keeping the machines and other facilities in a condition that allows them to be used without any interruption and at their maximum profit making capacity. (Adegoke, 2003).However, as adequate care is being taken to ensure the reconditioning of the machine and building facilities back to their original state, a level at which it will be able to perform the intended use, however cognizance should be taken of the fact that, if it has to be done; it should be at minimum cost, with improved output, emphasis placed on employee involvement and empowerment, continuous improvement, cutting across the entire organization, and with every responsibility for quality of work output. (Wahab, 1987 and Iyagba, 2005).

According to Olawunmi (1992), the consequence of neglecting the aspect of management of quality in the maintenance of facilities, machines, and buildings, has resulted in the increase in maintenance cost and low building performance, wasted energy and effort, inadequate client's management of maintenance example Lack of communication regarding maintenance issue, Inadequate resources allowed for adequate maintenance, capital cost overriding life-cycle-cost, very complex service system with low reliability and lack of sufficient instrumentation for easy monitoring.

Empirical literature evidence are not conclusive concerning maintenance practice in foundry. This calls for the need to maintenance practices for effective foundry practice in Minna metropolis of Niger State.

1.2 Statement of the Problem

There exists general information which is easily accessible about the location, products and activities of manufacturing companies. However there is insufficiency of information on maintenance activities being undertaken within the industry. Adejuyigbe, (2006) reports that there are some levels of maintenance activities taking place within manufacturing industries but offer no specific details; for example the type of maintenance strategy adopted, equipment and technology employed, the role of the maintenance manager, training, documentation and influence on performance among others.

Maintenance culture such as preventive and corrective approaches which comprise of provision for adequate care of the hard earned infrastructure have not gained ground in the consciousness of resource managers in the manufacturing firms over the years. This condition has resulted in abandoned factory plants, dilapidated buildings, deserted vehicles with minor problems, moribund industries and a host of other properties which have little or insignificant problems. The ugly consequence is economic stagnation, poor quality, huge operating cost to these firms and subsequent collapse which aggregate to national economy. Specifically, the study sought to study the maintenance practices for effective foundry practice and the problems inherent in the need for proper implementation of the maintenance practice. It is the investigation into the maintenance practices for effective foundry practice that this study intend to determine Aminu, (1990).

1.3 Purpose of the Study

The main purpose of this study is to identify the maintenance practices for effective foundry practice in Minna Metropolis of Niger State. Specifically, the study seek to:

1. Find out the corrective maintenance practice for effective foundry practice
2. Determine the preventive maintenance practice for effective foundry practice
3. Find out the challenges of proper maintenance practices for effective foundry practice

1.4 Significance of the Study

The findings of this study will be beneficial to students, Curriculum Planners, Ministry of Education, Parents and Society

The student will benefit from the facilities provided by maintenance practice for proper manpower development. The student will also benefit from the findings of this study as it will enable them to know how to maintain their facilities for long lasting usage.

The curriculum planners will make use of the findings during innovations; it'll assist them to ascertain how they set goals and objectives of foundry practices have been achieved and as well seek for improvements where necessary.

The study will also sensitize the ministry of education in other to monitor and inspect the school in other to know what is needed in schools to achieve effective teaching and learning school and to inform the government in other to raise found on educational system so that the necessary facilities will be available for teacher for effective teaching.

The study will bring an awareness of the usefulness and help the society to be able to give every members of the society proper education on maintenance practice in order to acquire proper skill and knowledge of foundry.

1.5 Scope of the Study

This study will be carried out to identify the maintenance practices for effective foundry practice in Minna Metropolis of Niger State. This study covered only maintenance practices. Due to the constraints, extent and adequacy of maintenance practices will not be covered.

1.6 Research Questions

1. What are the corrective maintenance practice for effective foundry practice?
2. What are the preventive maintenance practice for effective foundry practice?
3. What are the challenges of proper maintenance practices for effective foundry practice?

1.7 Hypotheses

The following null hypotheses will be tested in the study:

H_{01}: There is no significant difference in the mean response of metalworkers and metalwork teachers on the corrective maintenance practice for effective foundry practice.

H_{02}: There is no significant difference in the mean response of metalworkers and metalwork teachers on the preventive maintenance practice for effective foundry practice.

H_{03}: There is no significant difference in the mean response of metalworkers and metalwork teachers on the challenges of proper maintenance practices for effective foundry practice.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

The review of related literature to this study is organized under the following subheadings:

2.1 Conceptual Framework

2.1.1 The Concept of Maintenance

2. 1.2 Maintenance practice

2. 1.3 The concept of preventive maintenance.

2. 1.4 The Concept of Performance

2. 1.5 Foundry Technology in Technical institutions

2.2 Related Empirical Studies

2.3 Summary of Review of Related Literature

2.1 Conceptual Framework

2.1.1 The Concept of Maintenance

There are many definitions of maintenance. Telang and Telang (2010) define maintenance as "the combination of all technical and related administrative actions including supervision, with an aim to retain an item in, or restore it to a state in which it can perform a required function". This definition clearly identifies two distinct activities in maintenance; the technical and the administrative. The technical activities are grouped under maintenance engineering and deal with the actual tasks carried out on equipment while the administrative activities are grouped under maintenance management and basically deal with the management aspects of maintenance. (Chiekezie, Nzewi and Odekina, 2017), observes that maintenance is a means to maintain and improve the quality of the elements involved in a production process, continuously and cost-effectively through detecting and controlling the deviations in the condition of a production process.

Maintenance can be summarized as the repair and upkeep of existing equipment, buildings and facilities to keep them in a safe, effective and desired condition so that they can meet their intended purpose Seniwoliba, (2022).

Maintenance strategies are generally categorized as corrective (reactive) and preventive (proactive). The corrective maintenance is an unscheduled maintenance attempting to restore a system after a failure occurs. The preventive maintenance on the other hand is to schedule proactive maintenance routinely by designed inspection, detection, and repair/replacement (Adeyeri,Kareem, Ayodeji, &Emovon, 2011).

Needs for Maintenance

A thorough adherence to a well-defined and developed maintenance strategy will take care of facility breakdown or malfunction thereby allowing facility managers to concentrate on capitalisation (Abiodun, Olayemi and Joseph 2016). In the absence of this, measurable time will be required to develop and define a maintenance strategy, communicate it, and last focusing on the tactical choice, for how to achieve it. Tactics are the actual activation needed to implement the strategy, which concerns the management of processes, people, and physical asset infrastructure (Pezeshkian and Hamidi 2019). The management's objectives must be realized in accordance with safety, environmental regulations and also in a cost effective way. The integration of machines, men, methods and means into a well-designed strategy requires indispensable managerial capacity (Waeyenberghad & Pintelon, 2002).

Below are some of the accruable benefits if maintenance culture is embraced in our society:

Keeping assets in utmost working condition in order to minimize downtime and disruption to services

- Keeping facilities in a state of good repair for the owner's health and safety
- Keeping assets from deteriorating in appearance and aesthetics
- Keeping facilities so as to optimally achieve their full potential service life
- Leveraging efficiencies that can be reflected on the owner's statement of financial position
- Satisfying a legislated duty that is owed to owners, occupants and guests on the property
- Preventing unnecessary damage to assets or facilitation that may result in their performance failure

Types of maintenance

Planned maintenance: The maintenance organized and carried out with fore thought, control and the use of records to a predetermined plan.

Unplanned maintenance: The maintenance carried out to no predetermined plan. This is the restoration of sudden defective facility to its functional state.

Preventive maintenance: The maintenance carried out at predetermined intervals or corresponding to research criteria and intended to reduce the probability of failure or the performance degradation of an item. Preventive maintenance is an action performed on a time or machine run based schedule that detect, preclude, or mitigate degradation of a component or system with the aim of sustaining or extending its useful life though controlling degradation to an acceptable level Sreejit, et al (2018). This approach to maintenance management is predominantly recurring or time-driven tasks performed to maintain acceptable levels of availability and reliability Doostparast, et al (2015). Comprehensive preventive maintenance programs schedule repairs, adjustments machine rebuilds for all critical equipment while more limited programs only consist of minor adjustments and lubrication. The scheduling guideline for these programs is the common denomination due to the fact that, all preventive maintenance management programs assume that equipment will degrade within a certain period of time Doostparast, et al (2015). The strategy is cost effective, energy saving as well as increased component life cycle and reduced equipment or process failure.

Corrective maintenance: The maintenance carried out after a failure has occurred and intended to restore an item to a state in which it can perform its required function. This maintenance strategy is simple and straightforward, “fix it when it breaks” Doostparast, et al (2015) i.e. the defective items are fixed either after failure or during failure (Khazraei and Deuse 2011). The corrective technique does not take any maintenance action until failure occurred. This maintenance management philosophy is rarely used altogether without any preventive tasks, (lubrication and adjustment). Still, in a corrective environment, the equipment are not rebuilt nor repaired in greater extent until it fails to operate (Mobley, 2004). This enjoyed low cost investment for maintenance and few staff is required.

Emergency maintenance: The maintenance which is necessary to put in hand immediately failure occurred to avoid serious consequences, Doostparast, et al (2015). This is sometimes referred to as day-to-day maintenance, resulting from such incidences as gas leaks and damage.

Schedule maintenance: The preventive maintenance carried out to a predetermined, say, interval of time, number of operations or mileage.

Condition-based maintenance: The preventive maintenance initiated as a result of knowledge of the condition of an item from routine or continuous monitoring

2. 1.2 Maintenance Culture

Culture is difficult to define because it have multitude concept, each with own slight variation depending on the focus of study. It is a way of life which consist language, arts and thought, spiritually, social activity and interaction. Generally, culture is acknowledged as encompassing inherited ideas, beliefs, values and knowledge that contribute the shared bases of social actions Sani, et al (2011). Culture is the key that influences behaviour of getting things done the right way without which would hinder the goals from being achieved Uma, et al (2014).Culture is shaped by the interaction between individual and groups shared the value, perception and goal they have learned previous generation continues to generation. The context of culture has been use in organisation when culture is created in the organisation of social relationship among members through way thinking, behavior and belief. In general, culture is defined as the overall activity of human behavior, the arts, belief, values, attitudes, practices, and all human works and ideas that influences each member in the organisation. Culture in an organisation is a pattern of shared basic assumptions that the group learned as it solve its problem of external adaptation and internal integration that has worked well enough to be considered valid and therefore, to be taught to new members as a correct way to perceive, think and feel in relation to those problems (Bolaji and Adejuyigbe, 2012). Grosenick and Gibson (2019), maintains that the significance of cultural approach to maintenance activities is that it allows a general view of the social dynamics in a complex and diverse domain.

Maintenance culture focuses on the design and implementation of a technical procedure that supports the prevention or correction of premature failure of engineering systems with least cost and time without compromising the system performance and safety parameters Wahyuni, et al (2022). Developing good maintenance culture in industries requires a human resources organisational framework. The strategies would be based on definite corporate focus and objectives while the functionality of the human element depends on factors like qualification, motivation, inter-personal relationships, training and retraining. It has been found that a good production system is usually backed up by an effective maintenance system; therefore, evaluating maintenance culture is an important ingredient in the effort to enhance productivity in the manufacturing industries (Chiekezie, Nzewi and Odekina, 2017).

2. 1.3 The concept of preventive maintenance.

Gupta and Jain (2021) notes that preventive maintenance is the routine inspection and service activities designed to detect potential failure conditions and make major adjustments or repairs that will be of help to prevent major operating problem. The preventive maintenance policy is a system of planned and scheduled maintenance. The basic principle involved in this system is "prevention is better than cure" it includes.

- Proper identification of all items, their documentation and coding
- Inspection of plant and equipments at regular interval (periodic inspection)
- Proper cleaning, lubrication of equipments. To upkeep the machine through minor repairs and major overhauls.
- Failure analysis and planning for their elimination.

Preventive maintenance schedules are normally of two categories

- Fixed time maintenance (firm) schedule
- Condition based maintenance.

Williams, et all (2021) observes that preventive maintenance (PM) is a fundamental, planned maintenance activity designed to improve equipment life and avoid any unplanned maintenance activity. This maintenance includes, Systematic inspection, detection of the entire maintenance which is the foundation of the entire maintenance strategy. Unless the PM program is effective, all subsequent maintenance strategies take longer to implement, incur higher costs, and have a higher probability of failure.

2. 1.4 The Concept of Performance

The concept of performance lends itself to an almost infinite variety of definitions, many of which relate to specific contexts or functional perspectives. Adejuwon, (2016) gave a general definition and well-crafted definition of performance, sharing the concept of two primary components, efficacy and effectiveness. Efficiency refers to performance in terms of inputs and outputs so that the resulting higher volume for a given amount of inputs, means greater efficiency. Effectiveness refers to the performance by the degree to which planned outcomes are achieved (for example: objective to avoid interruptions of supply over a period of time can be regarded as an efficient outcome).

Many previous definitions of performance tended to focus on the size of efficiency, showing financial results as a primary measure of performance. Subsequently, this concept's definitions have evolved, especially with the emergence of the Balanced Scorecard Kaplan (2012) which includes not only the financial perspective, but also the internal perspective, customer perspective and innovation and learning perspective. Performance can be expressed through a balanced set of parameters describing the results and processes to achieve these results.

Construction business performance is achieved by balancing and interrelation of at least four forces Pintea and Achim, (2010):

- Efficiency of production processes;
- Shareholders' meeting requirements;
- Customer satisfaction;
- Capacity of the growth and development - staff skills (training, satisfaction), the degree
- of innovation, use of opportunities.

Performance is the execution or accomplishment of work, tasks or goals to a certain level of desired satisfaction. In this study, however, organisational performance is defined in terms of the ability of an organisation to satisfy the desired expectations of three main stakeholders comprising of owners, employees and customers (Aluko, 2003). This is measured in terms of the following parameters:

- Owners' satisfaction with costs reduction and financial returns or profits from organisational operations.

- Employees' satisfaction with the conditions of work, such as wages and remuneration, style of supervision, rapid promotion and the ability of the organisation to guarantee job security.
- Employees' expressed a desire to stay with the organisation, i.e., the ability of the organisation to retain its workforce.
- Customers' expressed satisfaction with the quality of the products of the organisation.

2. 1.5 Foundry Technology

Foundry technology is among the skilled areas studied in technical institutions. Foundry technologies involve the processes of making castings in mould formed in either sand or some other materials (Jain, 2008). It is a collection of necessary materials, tools and equipment to produce a casting. Foundries produce ferrous and non-ferrous metal castings. Ferrous castings are comprised of iron and steel, while non-ferrous castings primarily include aluminum, copper, zinc, lead, tin, nickel, magnesium, and titanium. Castings are produced by melting, pouring, and casting the ferrous and non-ferrous metals. Many foundries cast both types of materials.

Ferrous castings typically include:

- Grey cast iron, with good damping and machinability characteristics, but lower durability;
- Malleable cast iron, containing small amounts of carbon, silicon, manganese, phosphorus, sulfur and metal alloys;

- Spheroidal graphite cast iron (SG), obtained by removing the sulfur from the melt of cast iron;
- Cast carbon steel (low-medium-high), with superior strength, ductility, heat resistance, and weldability compared to iron casting.

Non-ferrous metals are produced to meet product specifications such as mechanical properties, corrosion resistance, machinability, lightness, and thermal and electrical conductivity. Non-ferrous casting includes many non-ferrous compounds, such as: aluminum and aluminum alloys; copper and copper alloys; zinc and zinc alloys; magnesium and magnesium alloys; cobalt-base alloys; nickel and nickel alloys; titanium and titanium alloys; zirconium and zirconium alloys; and cast metal-matrix composites.

Common non-ferrous alloys include: copper – zinc alloy (Brass); copper – tin alloy (Bronze); nickel-copper alloys (monel/cupronickel); nickel-chromium-iron alloys (stainless steel); aluminum-copper alloys; aluminum-silicon alloys; aluminum-magnesium-alloys; and titanium alloys.

The Foundry (Casting) Processes

Many different casting techniques are available. All involve the construction of a container (mould) into which molten metal is poured. Two basic casting process subgroups are based on expendable and non-expendable mold casting. Expendable mould casting, typical to ferrous foundries although also used in non-ferrous casting, uses lost moulds (e.g. sand moulding). Non-expendable mould casting, adopted mainly in non-ferrous foundries, uses permanent moulds (e.g. die-casting). Lost moulds are separated from the casting and destroyed during the shakeout phase, while permanent moulds are reused. A variety of techniques are used within these two mould casting processes depending on the melting, moulding and core-making systems, the casting system, and finishing techniques applied.

A typical foundry process, outlined in Figure A.1 below, includes the following major activities: Melting and metal treatment in the melting shop; preparation of moulds and cores in the molding shop; casting of molten metal into the mould, cooling for solidification, and removing the casting from the mould in the casting shop; and finishing of raw casting in the finishing shop.

Melting Shop

Different types of melting furnaces and metal treatments are used to produce ferrous and non-ferrous materials depending on the type of metal involved.

- *Cast iron* is typically melted in cupola furnaces, induction furnaces (IF), electric arc furnaces (EAF), or rotary furnaces. Use of induction furnaces (coreless induction-type furnace for melting and channel induction-type for holding) is preferred over cupola furnaces due to their superior environmental performance. EAFs are employed less commonly.
- *Cast steel* is typically melted in electric arc furnaces or coreless induction furnaces. Cast steel metal treatment consists of refining (e.g. removal of carbon, silicon, sulfur and or phosphorous) and deoxidization depending on the charge metal and required quality of the casting product. Melted metal may require treatments such as desulfurization, and deslagging. To remove impurities in the melt, metal flux is added to the furnace charge or to the molten metal. Flux unites with impurities to form dross or slag which is removed before pouring.

Cupola Furnaces

The cupola furnace is the common furnace used for cast iron melting and the oldest type of furnace used in foundries. It is a cylindrical shaft type furnace lined with refractory material. The furnace uses coke as a fuel and combustion air. Molten iron flows down the cupola furnace while combustion gases move upward leaving the furnace through its stack. As melting proceeds, new material is added at the top of the shaft through a charging door. Added flux combines with non-metallic impurities in the iron to form slag, which is lighter than molten iron and floats on the top of the molten metal protecting it from oxidation. The liquid metal is tapped through a tap-hole at the level of the sand bed and collected into a ladle and / or a holding furnace. The slag is removed through a hole at higher level. Coke accounts for 8–16 percent of the total charge to provide the heat needed to melt the metal. Melting capacities of cupola furnaces generally range from 3 to 25 metric tons per hour.

Cupola furnaces require a reducing atmosphere to prevent oxidation of the iron as it is melted. Oxidization is minimized by assuring the presence of carbon monoxide (CO) in the combustion gas (about 11-14 percent CO content). This results in inefficient use of the available energy in the coke, and significant CO emissions to the environment. Alternative technologies can be used to increase the efficiency of the cupola furnace and reduce CO emissions. These include preheating combustion air up to 600°C as performed in the Hot Blast cupola20; oxygen enrichment; or supersonic direct injection of pure oxygen.

The cupola process also produces a significant amount of particulate emissions. Emission control systems typically require use of high energy wet scrubbers or dry bag- house (fabric filter) systems.

Electric Arc Furnaces (EAF)

The EAF is a batching furnace often used in large steel foundries. Its use for cast iron production is less common. The EAF is shaped as a ladle. Heat required to melt the metal is produced with an electric arc from electrodes, initially positioned above the charge. The furnace is tapped by tilting it and forcing the molten metal to flow out through the tapping spout. Opposite the tapping spout is an operating door that allows deslagging and sampling operations.

Induction Furnaces

Induction furnaces (IF) are used for melting ferrous and nonferrous metals. Melting is achieved through a strong magnetic field created by passing an alternating electric current through a coil wrapped around the furnace and consequently creating an electric current through the metal. The electric resistance of the metal produces heat, which melts the metal itself. These furnaces provide excellent metallurgical control and are relatively pollution free. The most significant air emissions released by IFs relate to the charge cleanliness resulting in the emission of dust and fumes (organic or metallic). Other emissions result from chemical reactions during holding or adjusting the metal composition, which originate metallurgical fumes.

Reverberatory or Hearth Furnaces

Reverberatory or hearth furnaces are used for batch melting of non-ferrous metals. It is a static furnace with direct heating and consists of a refractory-lined, rectangular or circular bath furnace that is fired by wall or roof mounted burners. Hot air and combustion gases from the burners are blown over the metal charge and exhausted out of the furnace. In addition to the oil or gas fuel burners, oxy-fuel burners may also be used to increase the melting rate. These furnaces are typically used for small scale production as emissions control is difficult.

Crucible Furnaces

Crucible furnaces are used primarily to melt smaller amounts of non-ferrous metals. The crucible or refractory container is heated in a furnace fired with natural gas, liquid fuel (e.g. propane) or by electricity. The crucible is either tilted manually, with a crane, or automatically, to pour the molten metal into the mold.

Rotary Furnaces

The rotary furnace consists of a horizontal cylindrical vessel in which the metallic charge is heated by a burner located at one side of the furnace. The flue gases leave the oven through the opposite side. Once the metal is melted, and after a composition check and adjustment, a tap-hole in front of the furnace is opened and the melt in the furnace is discharged into ladles. Rotary furnaces are used for melting volumes of 2 to 20 tones, with typical production capacities of 1 to 16 tones per hour. Emissions control is often difficult.

Rotary furnaces have been used in non-ferrous melting for many years. In this type of furnace, traditional oil-air burners can provide relatively low melting temperatures. The development of oxygen-air burners has enabled their use in cast iron production, using a higher amount of steel scrap and applying graphite for carburization.

Shaft Furnaces

Shaft furnaces are only used for non-ferrous metal melting, mainly for aluminum. It is a simple vertical furnace with a collecting hearth (inside or outside the furnace) and burner system at the lower end, and a material charging system at the top. The burners are usually gas-fired.

Combustion gases are usually extracted and cleaned. An afterburner is sometimes used to treat any carbon monoxide, oil, volatile organic compounds (VOC), or dioxins produced.

Radiant Roof Furnaces

Radiant roof furnaces are mainly used in non-ferrous (aluminum) pressure die-casting shops with centralized melting facilities. The radiant-roof furnace is a low-energy holding furnace with a heavily insulated box design with banks of resistance elements in a hinged, insulated roof. Typical units have capacities of 250 – 1000 kilograms (kg).23

Moulding Shop

Before metal casting can take place, a mould is created into which the molten metal is poured and cooled. The mould normally consists of a top and bottom form, containing the cavity into which molten metal is poured to produce a casting. To obtain tunnels or holes in the finished mold (or to shape the interior of the casting or that part of the casting that cannot be shaped by the pattern) a sand or metal insert called a “core” is placed inside. The materials used to make the moulds depend on the type of metal being cast, the desired shape of the final product, and the casting technique.

Moulds can be classified into two broad types:

- *Lost moulds (single use moulds):* These are specially made for each casting and are destroyed in the shake-out process. These molds are generally made of sand and are clay-bonded, chemically bonded, or sometimes unbonded. Investment casting (lost wax) can also be included in this family;

- *Permanent moulds (multi-use moulds*): These are used for gravity and low-pressure casting, high pressure die-casting, and centrifugal casting. Typically, permanent moulds are metallic.

Sand is the most common moulding material used. Sand grains are bonded together to form the desired shape. The choice of binder technology used depends on factors such as the casting size, the type of sand used, the production rate, the metal poured, and the shakeout properties. In general, the various binding systems can be classified as either clay-bonded sand (green sand) or chemically-bonded sand. The differences in binding systems can have an impact on the amount and toxicity of wastes generated and potential environmental emissions. Green sand, which is a mixture of sand, clay, carbonaceous material, and water, is used as a mould in 85% of foundries. The sand provides the structure for the mould, the clay binds the sand together, and the carbonaceous materials prevent rust. Water is used to activate the clay. The mould must be dry otherwise it may present a risk of explosion.

Green sand is not used to form cores, which require different physical characteristic than mould. Cores should be strong enough to withstand the molten metal and collapsible so they can be removed from the metal piece after cooling. Cores are typically obtained from silica sand and strong chemical binders placed in a core box. The hardening or curing of the chemical binding system is obtained through chemical or catalytic reactions, or by heat. Sand cores and chemically-bonded sand moulds are often treated with water-based or spirit-based blacking to improve surface characteristics. The advantages to using chemically bonded moulds over green sand moulds include a longer storage life for the moulds; a potentially lower metal pouring temperature; and better dimensional stability, and surface finish to the moulds.

Disadvantages include higher costs of chemical binders and energy used in the process; added complexity to reclaim used sand; and environmental and worker safety concerns related to air emissions associated with binding chemicals during curing and metal pouring.

Sand moulding involves the use of large volumes of sand, with sand-to-liquid metal weight ratios generally ranging from 1:1 to 20:1. After the solidification process, the mould is broken away from the metal piece in a process called “shake-out” whereby the sand mould is shaken from the metal parts. Most of the used sand from green sand moulds is reused to make future moulds. Reused sand mixtures are also often used to create cores. However, a portion of sand becomes spent after a number of uses and needs to be disposed of. For this reason, mould and core making are a large source of foundry waste.

Investment casting, also known as the lost wax process, is one of oldest manufacturing processes. It is used to make parts with complex shapes or for high-precision metal castings. An investment mold is obtained by pouring, around (investing) a wax or thermoplastic pattern, slurry which conforms to the pattern shape and subsequently sets to form the investment mould. After the mould has dried, the pattern is burned or melted out of the mould cavity and the mould is ready to be utilized.

Permanent metal moulds are typically used in foundries producing large quantities of the same piece. They can be used for casting both ferrous and non-ferrous metals as long as the mould metal has a higher melting point than the casting metal. Metal moulds are used for gravitational casting, low and high pressure die-casting, and centrifugal casting. Cores for permanent moulds can be made of sand, plaster, collapsible metal, or soluble salts.

Casting Shop

Pouring the melted metal is the most significant activity in the casting process. Different pouring systems are used depending on the mould and metal type used for casting. The mould can be filled with the liquid metal by gravity (lost mould) or by injection under low or high pressure (die-cast) or by centrifugal forces. A pouring furnace is often utilized in automatic casting lines. This casting furnace automatically feeds the moulds in the casting lines and is refilled with liquid metal at fixed time intervals. Correct introduction and distribution of poured metal into the mould are provided by a set of columns and channels inside the mould (a "runner system" or "gating system"). The shrinkage (the difference in volume between liquid and solid metal) is compensated by the presence of an adequate feeder reservoir (a "riser"). After pouring, the casting is cooled to allow for solidification (first cooling) and it is then removed from the mould for further controlled cooling (second cooling). In sand casting foundries, sand castings enter the shakeout process to remove the mould after solidification. During shake-out, dust and smoke are collected by dust-control equipment. Investment moulds and shell moulds are destroyed during removal, creating solid waste. When the permanent mould technique is used, the mold (die) is opened and the casting extracted without destroying the mould after solidification. Some foundries treat mould and core sand thermally to remove binders and organic impurities before recycling to the mould-making facility.

Since various additives are used in the manufacture of the moulds and cores to bind the sand during metal pouring activities, reaction and decomposition products are generated. These include organic and inorganic compounds (Amines and VOC). The generation of decomposition products (mainly VOC) continues during the casting, cooling, and removing operations. Since these products may cause health and odor hazards, they should be extracted and the gas cleaned prior to release.

Finishing Shop

All remaining operations necessary to yield a finished product are conducted in the finishing shop. Depending on the process used, different steps may be required such as removal of the running and gating system, removal of residual moulding sand from the surface and core remains in the casting cavities, removal of pouring burrs, repair of casting errors, and preparation of the casting for mechanical post-treatment, assembly, thermal treatment, and coating. The metal piece is cleaned using steel shot, grit, or other mechanical cleaners to remove any remaining casting sand, metal flash, or oxide. Flame cut-off devices and air-carbon arc devices may also be used for this purpose. Small items are usually ground by tumbling, which is carried out in a rotating or vibrating drum. This usually involves the addition of water, which may contain surfactants. Residual refractory material and oxides are typically removed by sand blasting or steel shot blasting, which can also be used to provide the casting with a uniform and improved surface appearance. Welding may be required to join castings, as well as to repair casting flaws. Chemical cleaning of castings may be carried out before coating operations to ensure that the coating will adhere to the metal.

2.3 Related Empirical Studies

Udu (2014) carried out a study to identify the technical skills required by teachers of foundry technology in technical colleges in Kano state, Nigeria. Four research questions were developed and answered while four null hypotheses were formulated and tested at 0.05 level of significance at 31 degrees of freedom. Descriptive survey research design was adopted for the study. The entire population of 33 respondents consisting of 26 teachers and 7 instructors in technical colleges were used for the study. A 123-item structured questionnaire, developed from the literature reviewed for the study was used to collect data from the respondents. Each questionnaire item had a 4 response options of highly required, averagely required, slightly required and not required. The questionnaire items were face validated by five experts. The internal consistency of the questionnaire was determined using Cronbach alpha method and coefficients of 0.83 were obtained for technical skill questionnaire. The 33copies of questionnaire were administered on the respondents with the help of four research assistants. 33 copies of the questionnaire administered were all retrieved and analyzed. Weighted mean, and standard deviation were used to answer the research questions while t-test statistics was used to test the null hypotheses. The findings of the study revealed that 34 items in pattern-making, 41 items in mould and core-making, 28 items in melting and casting, 20 items in finishing and quality control were required for effective teaching of students in technical colleges in the study area. The findings on hypotheses revealed that there was no significant difference in the mean ratings of the respondents (teachers and instructors) in pattern-making, moulding and core-making, melting and casting, finishing and quality control that were required by teachers of foundry technology in technical colleges. It was therefore recommended that the teachers of foundry technology should utilize the identified skills in foundry technology to seek for sponsorship from their administrators to re-train themselves in the areas of their deficiency.

Saheed (2016) carried out a study on Lack of Maintenance Culture in Nigeria: The Bane of National Development. Lackadaisical attitude of Nigerians on maintenance culture has negatively affected infrastructural development which is critical and essential to a Nation's development. Achieving vision 2020 goals would be attainable if existing structures and facilities are constantly maintained. Poor maintenance culture has drawn the nation a thousand steps backward and one of the stride actions that could salvage the country from the total mess of infrastructural decay is maintenance. This paper aimed at examining lack of maintenance culture through review of archival materials and participative observations. Poor leadership, corruption, attitudinal problem and lack of maintenance policy were identified as major causes of the menace. In conclusion, the paper recommends the inclusion of maintenance culture in national educational curriculum, maintenance policy formulation and appointment of facility managers among others as necessary steps towards making the country among the comity of developed nations.

Obianuju (2017) conducted a research on maintenance culture and performance of selected manufacturing firms in Benue State, Nigeria. Manufacturing firms in Nigeria continuously face the problem of stoppage of production processes and high cost of repair due to inadequate knowledge of maintenance culture. The study seeks to examine the extent to which maintenance culture influences performance of selected manufacturing firms in Benue State, Nigeria.

The specific objective is to ascertain the extent to which preventive maintenance influences product delivery of selected firms. The study adopted survey design with a population of two hundred and thirty three (233) and a sample size of one hundred and forty seven (147) derived using Taro Yamane's formula for finite population. Questionnaire was used as instrument for data collection. Data collected were analysed with the use of Pearson Product Moment Correlation. The r value was subjected to a t-test of significance. Result shows that preventive maintenance significantly influences product delivery of the selected firms. The study recommended among others that firms should continuously adopt preventive and corrective measures of maintenance to reduce cost of repairs and intermittent stoppage of production processes. Firms should embark on continuous training programmes for their maintenance personnel as a pillar for proper maintenance culture development.

2.3 Summary of Review of Related Literature

The review of related literatures is discussed under the following subheadings: The Concept of Maintenance, Maintenance practice, The concept of preventive maintenance, The Concept of Performance, Foundry Technology in Technical institutions, Skills requirements of roadside mechanics. Adequate and relevant literatures were reviewed in the study.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Design of the Study

The study adopt the descriptive survey research design used to determine the maintenance practices for effective foundry practice in Minna Metropolis of Niger State. Survey design according Nworgu (1991) is aimed at collecting data on and describing in a systematic manner, the characteristics features or facts about a given population. .

3.2 Area of the study

The study will be carried out Minna Metropolis of Niger State.

3.3 Population for the Study

The population for the study consists of 80 respondents comprising 60 metalworkers and 20 teachers.

3.4 Sample and Sampling Technique

There will be no sampling since the population was small and manageable.

3.5 Instrument for Data Collection

The researcher designed a structured questionnaire as an instrument that will be used in collecting data for the study. The questionnaire was made up of four sections (A, B, C, and D). Section 'A' contains items on personal information of the respondents. Section 'B' seeks the corrective maintenance practice for effective foundry practice. Section 'C' find out the preventive maintenance practice for effective foundry practice. While Section 'D' find out challenges of proper maintenance practices for effective foundry practice. The questionnaire items were based on four points scale types. Items for section ‘B’, ‘C’ and ‘D’ contain four responses category each. The response categories for section ‘B’, ‘C’ and ‘D’ are strongly Agree (SA), Agree (A), and Disagree (D) and strongly disagree (SD). These response categories will be assign numerical values of 4, 3, 2 and 1 respectively. Respondents were require checking (√) against the response category that best satisfies their opinion.

3.6 Validation of instrument

The instrument will be validated by three lecturers in the department of Industrial and Technology Education, Federal University of Technology, Minna and contributions on the appropriateness of the instrument will be considered in the production of the final copy of the research instrument.

3.7 Reliability of instrument

In order to determine the reliability of the research instrument, a pilot test will be conducted using fifteen in other locations. During the test, the questionnaires were distributed by the researcher. The questionnaire was filled by the respondents and then returned to the researcher. The data collected will be analyzed using Crombach Alpha.

3.8 Administration of instrument

The instrument that will be used for the data collection will be administered to the respondents by the researcher and three research assistant in the study area.

3.9 Method of data analysis

Data collected will be analyzed using mean and standard deviation for the research questions while t-test will be used to test the hypothesis at the 0.05 level of significant. A four (4) point rating scale will be to analyze the data as shown below.

Strongly Agree	(SA)	=	4points (3.5 – 4.0)
Agree	(A)	=	3points (2.5 - 3.49)
Disagree	(D)	=	2points (1.5 – 2.49)
Strongly Disagree	(SD)	=	1point (1.0 – 1.49)

Therefore, the mean value of the 4 point scale is:

$$\bar{X} = \frac{4+3+2+1}{4} = \frac{10}{4} = 2.5$$

3.10 Decision Rule

The cutoff point of the mean score of 2.50 will be chosen as the agreed or disagreed point. This will be interpreted relatively according to the rating point scale adopt for this study. Therefore, an item with response below 2.49 and below will be regard or consider as disagreed while an item with response at 2.5 and above was regard or considered as agreed.

CHAPTER FOUR

PRESENTATION AND ANALYSIS OF DATA

4.1 Research Question 1

What are the corrective maintenance practice for effective foundry practice?

Table 4.1: Mean responses of the metalworkers and metalwork teachers on the corrective maintenance practice for effective foundry practice.

N_1= 60 N_2=20

S/N	ITEMS	$\bar{X}$	**SD**	Remark
1	Repair of faulty parts of machines	3.63	.517	Agreed
2	Overhauling of parts for effectiveness	3.57	.529	Agreed
3	Repair of furnace faults	3.60	.524	Agreed
4	Replacements of damage tools	3.58	.635	Agreed
5	Replacement of furnace lining when due	3.62	.550	Agreed
6	Repair of protective equipment	3.62	.550	Agreed

N=80

$\bar{X}$= mean of the respondents

N_1 = metalworkers

N_2= metalwork teachers

SD = standard deviation of the respondents

Table 4.1 showed that both the metalworkers and metalwork teachers agreed on all items from 1 to 6. This is because none of the mean response was below 2.50 which was the beach mark of agreed on the 4-points response options. The standard deviation score ranged between 0.517 and 0.635. This showed that the responses of the metalworkers and metalwork teachers on the items were not divergent.

4.2 Research Question 2

What are the preventive maintenance practice for effective foundry practice?

Table 4.2: mean response of the metalworkers and metalwork teachers on the productivity that women carry out in the construction industries.

N_1= 60 **N_2=20**

S/N	ITEMS	$\bar{X}$	SD	Remark
1	Clean Equipment Regularly to Minimize Dirt and Dust	3.63	.517	Agreed
2	Lubricate Rotating Parts to Prevent Premature Wear	3.57	.529	Agreed
3	Check Machinery Power to Optimize Energy Efficiency	3.60	.524	Agreed
4	Repair Equipment Before it Fails	3.52	.664	Agreed
5	Detecting potential equipment problems beforehand	3.63	.547	Agreed
6	Ensuring that purchasing specifications for new equipment incorporate all required safety features	3.58	.556	Agreed
7	Maintaining records of equipment installation, maintenance schedules, failures and repairs to assist in setting up inspection and preventive maintenance schedules	3.62	.550	Agreed
8	Providing training in the safe operation & maintenance of plant and equipment, including lockout and tag-out systems	3.57	.612	Agreed
9	The recharge enclosure of furnace should be cleaned at least once a shift, and the pour enclosure once a day	3.62	.521	Agreed
10	Removal of the residual solid metal and slag stuck to the furnace or ladle wall, then the removal of the refractory materials	3.69	.498	Agreed

N=80

$\bar{X}$= mean of the respondents

N_1 = metalworkers

N_2= metalwork teachers

SD = standard deviation of the respondents

Table 4.2 showed that both the metalworkers and metalwork teachers agreed on all items. This was because none of the mean response was below 2.50 which was the bench mark of agreed on the 4-point response options. The standard deviation score ranged between 0.498 and 0.612. This showed that the responses of the metalworkers and metalwork teachers on the items were not divergent.

4.3 Research Question 3

What are the challenges of proper maintenance practices for effective foundry practice?

Table 4.3: mean responses of the metalworkers and metalwork teachers on the challenges of proper maintenance practices for effective foundry practice.

		N_1= 60		**N_2=20**
S/N	ITEMS	$\bar{X}$	**SD**	Remark
1	Lack of adequate funds for maintenance processes	3.63	.486	Agreed
2	Poor response to maintenance needs	3.57	.499	Agreed
3	Lack of proper preventive maintenance	3.58	.497	Agreed
4	Lack of proper personnel training to maintain foundry machine	3.60	.607	Agreed
5	Poor work environment	3.62	.550	Agreed
6	Poor maintenance record keeping	3.66	.509	Agreed
7	Deficiency of craftsmen to carry out maintenance processes	3.68	.503	Agreed
8	Lack of usage of maintenance manual	3.71	.458	Agreed
9	Gross mismanagement of resources among craftsmen	3.63	.486	Agreed

N=80

$\bar{X}$= mean of the respondents

N_1 = metalworkers

N_2= metalwork teachers

SD = standard deviation of the respondents

Table 4.3 showed that both the metalworkers and metalwork teachers agreed on all items from 1 to 9. This was because none of the mean response was below 2.50 which was the bench mark of agreed on the 4-point response options. The standard deviation score ranged between 0.484 and 0.607. This showed that the responses of the metalworkers and metalwork teachers on the items were not divergent.

4.4 Hypothesis 1

There is no significant difference in the mean response of metalworkers and metalwork teachers on the corrective maintenance practice for effective foundry practice.

Table 4.4 T-test on corrective maintenance practice for effective foundry practice.

N_1 = 60 AND N_2 = 20

Respondents	N	X	SD	df	t-cal	P-value	Remark
metalworkers	60	3.43	0.73	78	0.624	0.006	NS
metalwork teachers	20	3.32	0.62				

N=80

$\bar{X}_1$ = mean of metalworkers

$\bar{X}_2$ = mean of metalworkers teachers

N_1 = metalworkers

N_2= metalworkers teachers

SD_1 = standard deviation of metalworkers

SD_2 = standard deviation of metalworkers teachers

NS=Not Significant

Table 4.4 showed that there was no significant difference in the responses of metalworkers and metalwork teachers on all the items as corrective maintenance practice for effective foundry practice; therefore the null hypothesis of no significant difference was upheld at 0.05 level of significance.

4.5 Hypothesis 2

There is no significant difference in the mean response of metalworkers and metalwork teachers on the preventive maintenance practice for effective foundry practice.

Table 4.5 T-test on the preventive maintenance practice for effective foundry practice.

$N_1 = 60$ AND $N_2 = 20$

Respondents	N	X	SD	df	t-cal	P-value	Remark
metalworkers	60	3.44	.445	78	.361	0.01	NS
metalwork teachers	20	3.30	.432				

NN=80

$\bar{X}_1$= mean of metalworkers

$\bar{X}_2$ = mean of metalworkers teachers

N_1 = metalworkers

N_2= metalworkers teachers

SD_1 = standard deviation of metalworkers

SD_2 = standard deviation of metalworkers teachers

NS=Not Significant

Table 4.5 showed that there was no significant difference in the responses of metalworkers and metalwork teachers on all the items as preventive maintenance practice for effective foundry practice; therefore the null hypothesis of no significant difference was upheld at 0.05 level of significance.

4.6 Hypothesis 3

There is no significant difference in the mean response of metalworkers and metalwork teachers on the challenges of proper maintenance practices for effective foundry practice.

Table 4.6 T-test on the challenges of proper maintenance practices for effective foundry practice.

N_1 = 60 AND N_2 = 20

Respondents	N	X	SD	df	t-cal	P-value	Remark
metalworkers	60	3.37	.225	63	.930	5.134	NS
metalwork teachers	20	3.54	.363				

N=80

$\bar{X}_1$**=** mean of metalworkers

$\bar{X}_2$ = mean of metalworkers teachers

N_1 = metalworkers

N_2= metalworkers teachers

SD_1 = standard deviation of metalworkers

SD_2 = standard deviation of metalworkers teachers

NS=Not Significant

Table 4.6 showed that there was no significant difference in the responses of metalworkers and metalwork teachers on all the items as challenges of proper maintenance practices for effective foundry practice; therefore the null hypothesis of no significant difference was upheld at 0.05 level of significance.

Findings of the study

The following are the main findings of the study; they are prepared based on the research questions and hypothesis tested.

1. The finding on the corrective maintenance practice for effective foundry practice showed that all the respondents agree on all the items, among all is Repair of faulty parts on machines.
2. The finding on the preventive maintenance practice for effective foundry practice showed that all the respondents agree on all the items, among all is Maintaining records of

equipment installation, maintenance schedules, failures and repairs to assist in setting up inspection and preventive maintenance schedules.

3. The findings on challenges of proper maintenance practices for effective foundry practice shows that showed that all the respondents agree on all the items, among all is Gross mismanagement of resources among craftsmen.
4. There was no significant difference in the responses of metalworkers and metalwork teachers on the corrective maintenance practice for effective foundry practice.
5. There was no significant difference in the responses of metalworkers and metalwork teachers on the preventive maintenance practice for effective foundry practice
6. There was no significant difference in the responses of metalworkers and metalwork teachers on the challenges of proper maintenance practices for effective foundry practice.

Discussion of findings.

The result from table 4.1 shows the findings on the corrective maintenance practice for effective foundry practice. The findings among others revealed that Repair of faulty parts on mixers and moulding machines, Overhauling of parts for effectiveness, Repair of furnace faults, Replacements of bad finishing tools, Replacement of furnace lining when due, Repair of proactive equipment. The findings of the study is inline with Doostparast, et al (2015) who stated that corrective maintenance is also called fix it when it breaks. So you fix foundry machine when they are faulty.

The result of the hypothesis on the corrective maintenance practice for effective foundry practice shows that there was no significant difference in the responses of metalworkers and metalwork teachers on the corrective maintenance practice for effective foundry practice.

Table 4.2 shows the result of the findings on preventive maintenance practice for effective foundry practice. The findings of the study reveals that Clean Equipment Regularly to Minimize Dirt and Dust, Lubricate Rotating Parts to Prevent Premature Wear, Check Machinery Power to Optimize Energy Efficiency, Repair Equipment Before it Fails, Detecting potential equipment problems beforehand, Ensuring that purchasing specifications for new equipment incorporate all required safety features, Maintaining records of equipment installation, maintenance schedules, failures and repairs to assist in setting up inspection and preventive maintenance schedules, Providing training in the safe operation & maintenance of plant and equipment, including lockout and tag-out systems, The recharge enclosure of furnace should be cleaned at least once a shift, and the pour enclosure once a day, Removal of the residual solid metal and slag stuck to the furnace or ladle wall, then the removal of the refractory materials. The findings of the study is inline with Sreejit, et al (2018) who stated that Preventive maintenance is an action performed on a time or machine run based schedule that detect, preclude, or mitigate degradation of a component or system with the aim of sustaining or extending its useful life though controlling degradation to an acceptable level.

The result of the hypothesis on the preventive maintenance practice for effective foundry practice shows that there was no significant difference in the responses of metalworkers and metalwork teachers on the preventive maintenance practice for effective foundry practice.

The result from table 4.3 reveal the findings on challenges of proper maintenance practices for effective foundry practice. The findings of the study revealed that Lack of adequate funds for maintenance proses, Poor response to maintenance needs, Lack of proper preventive maintenance, Lack of proper personnel training to maintain foundry machine, Poor work environment, Poor maintenance record keeping, Deficiency of craftsmen to carry out maintenance processes, Lack of usage of maintenance manual, Gross mismanagement of resources among craftsmen. The findings of the study is in with Aminu *et al.* (2019) who noted that many of the metalworkers lack adequate maintenance strategies in foundry operations.

The result of the hypothesis on the challenges of proper maintenance practices for effective foundry practice shows that there was no significant difference in the responses of metalworkers and metalwork teachers on the challenges of proper maintenance practices for effective foundry practice.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the Study

The main focus of this research study was to find out the maintenance practices for effective foundry practice in Minna Metropolis of Niger State.

Chapter 1 of the study discussed the background of the study, the statement of problem, purpose, significance, scope and the research questions were all stated and discussed for the conduct of this research.

The review of related literature looked into The Concept of Maintenance, Maintenance practice, The concept of preventive maintenance, The Concept of Performance, Foundry Technology in Technical institutions. Various views of different authors concerning the topic were harmonized in a comprehensive literature review and empirical studies.

A survey approach was used to developed instrument for the study; the respondents identified as the population of the study were the metalworkers and metalwork teachers. The entire respondents were used. A number of 80 questionnaires were administered. The instrument used was analysed using frequency count, and mean scores. The research questions were discussed base on the findings from the responses and results of the instrument used.

Implication of the study and conclusions were also drawn from the findings discussed. Recommendations and suggestions for further study were formulated and stated according to the findings of the study.

5.2 Implications of the Study

The findings of the study had implications for government, metalworkers and metalwork teachers. If the findings of the study on maintenance practices required in foundry technology, teachers/instructors of foundry technology in colleges could utilize the maintenance practices identified by this study in foundry technology effectively. The teachers/instructors could also become aware of their deficient areas and so make themselves available for re-training programme through workshops or in-service training in universities in order to equip themselves professionally and technically for their teaching job

5.3 Conclusion

Based on the findings of the study, the following conclusions were drawn: Teachers of foundry technology require appropriate maintenance practices for foundry technology. Both teachers and metalworkers of foundry technology collaboratively agreed on the maintenance practices. Interventions are needed on the part of college administration and government in organizing capacity building workshops or retraining of teachers utilizing identified maintenance practices in their need areas.

5.4 Recommendations

Based on the findings of the study, the following recommendations were made:

1. Teachers/instructors of foundry technology should utilize the findings of this study on the technical skills required to seek for sponsorship from their administrators in order to attend re-training programme for improving their competency in teaching foundry technology.
2. The administrators should utilize the findings of this study on the technical skills required in foundry technology as the areas their teachers needs improvement to approve requests from their teachers for sponsorship to participate in re-training programme to equip them effectively for teaching foundry technology to the students in their colleges.

3. The administrators of technical colleges should utilize the findings of this study on the maintenance practices required in foundry technology as areas where their teachers need improvement and organize internal workshops in their colleges for re-training of their teachers or they could use the information and solicit for fund from NBTE and other government agencies in order to improve their teachers professionally and technically for better performance of their job.

5.5 Suggestion for Further Study

The following are suggested for further studies:

1. Technical skill improvement needs of technical college teachers of foundry technology for effective teaching of foundry technology in technical colleges.
2. Material resource inputs into foundry technology for effective re-training of teachers of foundry technology in pattern-making, moulding and core-making, melting and casting, finishing and quality control in technical colleges.

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Appendix A

QUESTIONNAIRE

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE

SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION

DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION

A QUESTIONNAIRE ON MAINTENANCE PRACTICES FOR EFFECTIVE FOUNDRY PRACTICE IN MINNA METROPOLIS OF NIGER STATE

INTRODUCTION: Please kindly complete this questionnaire by ticking the column that best present your perception about the topic. The questionnaire is for research purpose and your view will be confidentially and strictly treated in response to the purpose of the research work.

SECTION A

PERSONAL DATA

Metalworkers: ☐

Metalwork teachers: ☐

Note: A four (4) point scale is used to indicate your opinion, tick the options which best describe your agreement as shown below:

Strongly Agree	(SA)	=	4points
Agree	(A)	=	3points
Disagree	(D)	=	2points
Strongly Disagree	(SD)	=	1points

Section B: What are the corrective maintenance practice for effective foundry practice?

S/N	**Items**	**Scales**			
		SA	**A**	**D**	**SD**
1	Repair of faulty parts on mixers and moulding machines				
2	Overhauling of parts for effectiveness				
3	Repair of furnace faults				
4	Replacements of bad finishing tools				
5	Replacement of furnace lining when due				
6	Repair of proactive equipment				

Section C: What are the preventive maintenance practice for effective foundry practice?

S/N	**Items**	**Scales**			
		SA	**A**	**D**	**SD**
1	Clean Equipment Regularly to Minimize Dirt and Dust				
2	Lubricate Rotating Parts to Prevent Premature Wear				
3	Check Machinery Power to Optimize Energy Efficiency				
4	Repair Equipment Before it Fails				
5	Detecting potential equipment problems beforehand				
6	Ensuring that purchasing specifications for new equipment incorporate all required safety features				
7	Maintaining records of equipment installation, maintenance schedules, failures and repairs to assist in setting up inspection and preventive maintenance schedules				
8	Providing training in the safe operation & maintenance of plant and equipment, including lockout and tag-out systems				

9	The recharge enclosure of furnace should be cleaned at least once a shift, and the pour enclosure once a day				
10	Removal of the residual solid metal and slag stuck to the furnace or ladle wall, then the removal of the refractory materials				

Section D: What are the challenges of proper maintenance practices for effective foundry practice?

S/N	**Skill Items**	**Scale**			
		SA	**A**	**D**	**SD**
1	Lack of adequate funds for maintenance proses				
2	Poor response to maintenance needs				
3	Lack of proper preventive maintenance				
4	Lack of proper personnel training to maintain foundry machine				
5	Poor work environment				
6	Poor maintenance record keeping				
7	Deficiency of craftsmen to carry out maintenance processes				
8	Lack of usage of maintenance manual				
9	Gross mismanagement of resources among craftsmen				