ASSESSMENT OF OIL EXTRACTS FROM TIGER NUT(*Cyperus esculentus*), WATER MELON (*Citrullus vulgaris*) andNEEM SEEDS (*Azadirachta indica*) AS CUTTING FLUIDS IN DRILLING OPERATION OF MILD STEEL.

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DEPARTMENT OF MECHANICAL ENGINEERING,
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AHMADU BELLO UNIVERSITY, ZARIA-NIGERIA

APRIL, 2016.

DECLARATION

I declare that the work in this dissertationentitled '**Assessment of Oil Extracts from Tiger nut(*cyperusesculentus*), Water melon (*citrullus vulgaris*) andNeem seeds (*azadirachtaindica*)as Cutting fluids in Drilling operation of Mild Steel'**has been carried out by me in the Department of Mechanical Engineering, Faculty of Engineering, Ahmadu Bello University, Zaria-Nigeria under the supervision of Engr. (Dr) F.O.Anafiand Engr. (Dr) M. Dauda.The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other institution.

Ibrahim Abubakar AMASA	……..…………………	……...…………….
Name of Student	Signature	Date

CERTIFICATION

This dissertation entitled "**ASSESSMENT OF OIL EXTRACTS FROM TIGER NUT(*Cyperus esculentus*),WATER MELON (*Citrullus vulgaris*) andNEEM SEEDS (*Azadirachta indica*)AS CUTTING FLUIDS IN DRILLING OPERATION OF MILD STEEL"** by Ibrahim Abubakar AMASA, meets the regulations governing the award of the degree of Master of Science (M.Sc) in Mechanical Engineering ofAhmadu Bello University, and is approved for its contribution to knowledge and literacy presentation.

Engr (Dr). F.O. Anafi……………………. …………………

Chairman, Supervisory Committee **Signature** **Date**

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Head of Department **Signature** **Date**

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Dean, School of Postgraduate Studies **Signature** **Date**

DEDICATION

This work is dedicated to Almighty Allah and the blessed memory of my late father,AlhajiAremuAbubakarAmasa. May Almighty Allah grant himAljanatulFirdaus.

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My utmost gratitude to the Almighty who taught by the pen and taught man what he knows not. May His peace and blessing be upon the chosen one.

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ABSTRACT

In this study, three vegetable cutting fluid namely: Tiger nut, water melon seed and neem seed were selected in drilling operation of mild steel using High Speed Steel (HSS) cutting tool at varying spindle speeds, feed rate and constant depth of cut. A commercially available convectional mineral oil was used as standard for comparative analysis. Flood method of cutting fluid application was adopted at the cutting zone for the cutting fluids, dry drilling environment was equally subjected to the same cutting parameters as the cutting fluids. The viability of these selected oil as cutting fluids were examined based on reduction in temperature generation, surface finish value and characteristics of chips produced. The results indicated that performance of selectedoil as cutting fluid in term of surface quality was best with water melon seed having 1.6µm surface roughness while conventional mineral oil was having 2.2µm at the same feed rate of 0.05 mm/rev, dry drilling condition was having 4.2µm as the highest value at this stated feed rate. The chips produced shows that all the cutting fluids were having segmented chip which is a good morphology at lower spindle speed but dry drilling environment was having 75% of its chip continuous, with substantial portion being burnt. Reduction in the generated temperature as the spindle speed increased was best achieved with water melon seed oil followed by mineral oil, tiger nut oil and neem seed oil respectively. The performance of selected plant cutting fluid are very similar because of their close physio-chemical properties.

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ABBREVIATION AND SYMBOLS

D_d……………………………………Diameter of drill, inches

d ………………………………….. Depth of cut, inches

E …………………………………….Efficiency of spindle drive

F_c…………………………………….Cutting force

F_m ………………………………….. Feed rate, inches per minute

F_r …………………………………… Feed, inches per revolution

F_t …………………………………….Feed, inches per tooth

hp_m …………………………………..Horsepower at motor

MRR ………………………………...metal removal rate, in^3/min

hp……………………………………....Horsepower at spindle

L ……………………………………..Length of cut, inches

n ……………………………………...Number of teeth in cutter

HP_s……………………………….....horsepower per cubic inch per minute

N_s…………………………………......Revolution per minute of work or cutter

T_m …………………………………....Cutting time, minutes

V……………………………………..Cutting speed, feet per minute

w …………………………………….Width of cut, inches

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Research

Machining is the manufacturing process by which parts can be produced to the desired dimensions and surface finish from a blank by gradual removal of excess material in the form of chips by the help of sharp cutting tools. Engineering components are however subjected to one form of machining or another during manufacturing, thus the application of a cutting fluid is very essential.

Cutting fluid also known as metal working fluid, coolants, cutting oils, machining fluids or lubricants, are fluids used in manufacturing industries as coolants and lubricants, designed specifically for metal working and machining processes. Cutting fluids are used to reduce the negative effects of heat and friction on both tool and workpiece.

Historically, the use of cutting fluids in metal cutting was first reported by F. Taylor in 1894. He observed that cutting speed could be increased up to 33% without reducing tool life by applying large amounts of water in the cutting zone (Avila and Abrao, 2001). The cutting fluids produce three positive effects in the process of machining, heatevacuation, lubrication on the chip–tool interface and chip removal (Lopez *et al.*, 2006).Cutting fluids are extensively used in drilling operations for removal of chips from the holes, thereby preventing drill breakages(Braga, *et al.*, 2002). Higher surface finish, quality and better dimensional accuracy are also obtained from cutting fluids (Sokovic and Mijanovic, 2001).

1.2 Statement of the Problem

The application of cutting fluidsin machining processes decreasesthe temperature during machining by spraying the coolant on the machining zone. However, growing environmental concerns such as renewability, biodegrability, safety and health of operators demand serious attention(Abdalla and Patel, 2006).These concerns over the use of mineral oil as lubricant, gives vegetable oils the drive in finding their ways into the lubricants for industrial and transportation applications (Gawrilow, 2003).

These oils indeed offer significant environmental benefits with respect to resource renewability, biodegradability, as well as providing satisfactory performance in a wide array of applications(Gawrilow, 2003).Tiger nut oil, water melon seed oil and neem seed oil are to be studied for their applicability and suitability as cutting fluid in drilling operation of mild steel.

In this research, the three selected plant oils namely: water melon seed oil, neem seed oil, and tiger nut oil were used as cutting fluid in the drilling of mild steel usingVertical Drilling Machine with High speed steel(HSS) cutting tool. ThePhysico-chemical properties of these oils which includerelative density, acid value, saponification value and viscosity were evaluated. Cutting parameters like spindle speed, feed rate, depth of cutwere varied in the process of drilling.Temperature generated, Surface roughness and chip thickness were measured on each of the sample of the workpiece.

1.3 Aim and Objectives

The aim of this research is to evaluate the effectiveness of using plant based oils as cutting fluid in metal drilling operation.

The specific objectives of this research are:

i. To carry out the Physico-chemical analysis of the selected oils.
ii. To find out the variation of temperature with spindle speed for various cutting fluidsand dry drilling environment.
iii. To study the variation of chip thickness with spindle speed for various cutting fluids and dry drilling environment.

iv. To study the variation of surface roughness with spindle speed for various cuttingfluids and dry drilling environment.

v. To compare and identify the best cutting fluid between the selected plant oil and the convectional soluble oil.

1.4 Significance of the study

The research is of utmost importancein the area of drilling operation with the applicability of selected plants oil namely; Tiger nut oil, water melon oil and neem seed oil as the cutting fluid.Theirenvironmental friendly nature in term ofbiodegrabilityand freetoxicity has greatly contributed to their choiceas potential cutting fluids in the drilling operation of mild steel.

1.5 Project Scope

This research is limited to the performanceof the selected plant oils with standard soluble oil in drilling of mild steel rod. Vertical drilling machine and high speed steel cutting tool were used in the machining operation. The drilling operation was carried out under different parameters such as spindle speed, feed rate and constant depth of cut. The surface roughness ofeach machined sample was analyzed in order to assess the effectiveness of the selected plant oil.

1.6 Justification for the Research.

Mild steel have been used greatly in construction industry with enormous drilling and cutting operation on structural trusses, water tanks, water pipes and other building related components. The inherent challenges associated with soluble oil as cutting fluid which plant oil have figured out in term of biodegrability, toxicity and renewability have made them prefer choice as cutting fluids in drilling operation of mild steel.

The availability of these vegetable plants in substantial quantities, their environmental friendly nature accounts for the use of oil extracts from these plant seeds and nut as cutting fluids.Investigation of the potentials of these selected oils, their efficiency in reducing heat generation and suitability in drilling of mild steel will make addition to the number of available eco-friendly plant extracts that could be used as lubricants for drilling operation.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction to Cutting Fluids

Cutting fluids are widely used throughout industry in many machining operations such as milling, grinding, boring, and turning. Large machining facilities use central fluid systems with capacities as high as 760 000 liters, and it is estimated that over380 million liters of metalworking fluids are used each year (Gunther and Sutherland, 1999).

Depending on the type of machining operation, the cutting fluid needed may be a coolant, a lubricant, or both. The effectiveness of cutting fluids depends on a number of factors, such as the type of machining operation, tool and workpiece materials, cutting speed, and the method of application. Water is an excellent coolant and can reduce effectively the high temperatures developed in the cutting zone. However, water is not an effective lubricant; hence it does not reduce friction. Furthermore, it causes the rusting of workpieces and machine-tool components. On the other hand, as we have seen, effective lubrication is an important factor in machining operations(Kalpakjian andSchmid, 2006).

The need for a cutting fluid depends on the severity of the particular machining operation, which may be defined as the level of temperatures and forces encountered, the tendency for built-up edge (BUE) formation, the ease with which chips produced can be removed from the cutting zone, and how effectively the fluids can be applied to the proper region at the tool-chip interface. The relative severities of specific machining processes in increasing order of severity are: sawing, turning, milling, drilling, gear cutting, thread cutting, tapping, and internal broaching (Kalpakjian andSchmid, 2006).

2.1.1 Types of Cutting Fluid

According to Smith (1987), cutting fluid can be classified into three forms, Solids, Liquid and gasses with the purpose of decreasing friction between the tool and chip formed. Cutting fluids are usually classified into four main categories: straight oils, water soluble oils, synthetics, and semi-synthetics oils.

(i) Straight Oils

Straight oils, so called because they do not contain water, andare basically petroleum, mineral based oils. They may have additives designed to improve specific properties (Tuholski, 1993). The major advantage of straight oils is the excellent lubricity they provided between the workpiece and cutting tool, straight oils are usually limited to low temperature, low speed operation(Tuholski, 1993).

(ii) Soluble Oils

Soluble oils are also called emulsions, water-soluble oils oremulsifiable oils a soap-like material;they are generally comprised of 60-90 percent petroleum or mineral oil, emulsifiers and other additives (Jarrard, 1993). When mixed, emulsifiers cause the oil to disperse in water forming a stable “oil-in-water” emulsion (Silliman and Perich, 1992). Soluble oils offer improved cooling capabilities and good lubrication due to the blending of oil and water (Oberg *et al.*, 1992). They tend to leave a protective oil film on moving components of machine tools and resist emulsification of greases and slide way oils (Silliman and Perich, 1992).

(iii) Synthetics Fluids

Synthetic fluids contain no petroleum or mineral oil base and instead are formulated from alkaline inorganic and organic compounds (Silliman and Perich, 1992). Synthetic fluids can be further classified as simple, complex or emulsifiable synthetics based on their composition

(SOEPA, 1993).Simple synthetic concentrates (also referred to as true solutions) are primarily used for light duty grinding operations (Silliman and Perich, 1992).Due to their wettability, good cooling and lubricity, emulsifiable synthetics are capable of handling heavy-duty grinding and cutting operations on tough, difficult-to-machine and high temperature alloys(Silliman and Perich, 1992).

(iv) **Semi-synthetics Fluids**

Semi-synthetic fluids also referred to as semi-chemical fluids, are essentially a hybrid of soluble oils and synthetics. They contain small dispersions of mineral oil, typically 2 to 30 percent, in a water-dilutable concentrate (Hydrick, 1994). They have better cooling and wetting properties than soluble oils, allowing users to cut at higher speeds and faster feed rates (SOEPA, 1993).

2.1.2 Functions of Cutting Fluid

Cutting fluids have traditionally been used in machining operations to lubricate the chip-tool and tool-workpiece interfaces, remove heat from the workpiece and cutting zone, flush away chips from the cutting area, and inhibit corrosion (Shaw, 1942).

Cutting fluids are used to optimize a lot of machining operation such as turning, drilling, boring, grinding and milling. The main aim of using cutting fluid is to reduce cutting zone temperature in order to increase tool life and also to gain good surface finish. (Diniz and Marcaroni, 2007). The prime functions of cutting fluid are effective cooling and lubrication. With supply of cutting fluids the friction is also reduced. This functions and effects require the cutting Fluids to be in a fluid form (Zajac, 2007).

2.1.3 Properties of Cutting Fluids

The desirable properties of cutting fluids in general are (Boston, 1952):

- High thermal conductivity for cooling,

- Good lubricating qualities,
- High flash point, should not entail a fire hazard,
- Must not produce a gummy or solid precipitate at ordinary working temperatures,
- Be stable against oxidation,
- Must not promote corrosion or discoloration of the work material,
- Must afford some corrosion protection to newly formed surfaces,
- The components of the lubricant must not become rancid easily,
- No unpleasant odour must develop from continued use,
- Must not cause skin irritation or contamination,
- A viscosity that will permit free flow from the work and dripping from the chips.

2.1.4 Selection of suitable Cutting Fluid

The selection of a cutting fluid depends on many related factors. The primary concerns are machinability of the material, compatibility and acceptability. The selection of the type of cutting fluid for use should be based on (El Baradie, 1996):

a) Type of machining processes

b) Type of machined workpiece material

c) Type of cutting tool material

(a) Type of Machining Processes

One of the most important factors in selecting a cutting fluid is the nature of machining operation. The various machining operations naturally differ in metal removal characteristics. The most difficult machining process will need to use more cutting fluid. Selection is, therefore a matter of assessing the severity of the machining operation and marrying it to the appropriate cutting fluid (El Baradie, 1996).

The cooling effect of cutting fluid is more important in drilling process because of its cutting speed which is generally low due to two cutting edges of drill tool. In conventional drilling operation, emulsion oils and sulphur or chlorine additive mineral oils should be selected (El Baradie, 1996).

(b) Workpiece materials.

The second parameter for selection of suitable cutting fluids in machining processes is the type of workpiece material. The application of cutting fluids should provide easy machining operation in all materials (El Baradie, 1996). In steel machining operation, generally the high pressure containing and additive cutting fluids are used therefore high pressure cutting oils should be selected (DeGarmo*et al*., 1984).

(c) Cutting tool materials

The third important factor for selection of cutting fluid in machining processes is the cutting tool material. Varieties of cutting tool materials are commercially available for all kind of machining processes, however high speed steel cutting tools can be used with all type of cutting fluids (El Baradie, 1996). High-speed steel (HSS) tools are so named because they were developed to cut at higher speeds. First produces in early 1900's, high speed steels are the most highly alloyed of the tool steel (Kalpakjian and Schmid, 2006).

However there are three possible modes by which a cutting tool can fail in machining as explained by Groover, M.P. (2010):

(a) Fracture failure: This mode of failure occurs when the cutting force at the tool point becomes excessive, causing it to fail suddenly by brittle fracture.
(b) Temperature failure:This failure occurs when the cutting temperature is too high for the tool material, causing the material at the tool point to soften, which leads to plastic deformation and loss of the sharp edge.

(c) Gradual wear:Gradual wearing of the cutting edge causes loss of tool shape, reduction in cutting efficiency, an acceleration of wearing as the tool becomes heavily worn, and finally tool failure in a manner similar to a temperature failure.

2.1.5 Tool Life

Tool life is defined as the length of cutting time that the tool can be used (Groover 2010). Operating the tool until final catastrophic failure is one way of defining tool life. Tool life is the time a tool will cut satisfactorily, it is expressed as the minutes between changes of the cutting tool (Davim 2008). The significant of tool life in drilling cannot be over emphasized because substantial time is lost either at the replacement or resetting of tools. However, in production, it is often a disadvantage to use the tool until this failure occurs because of difficulties in resharpening the tool and problems with work surface quality (Groover 2010).

2.1.6 Taylor's Tool Life Formula

The Taylor Equation for Tool Life Expectancy provides a good approximation.

$$V_c T^n = C \qquad (2.1)$$

A more general form of the equation is

$$V_c T^n \times D^x F^y = C \qquad (2.2)$$

where, V_c=cutting speed, T=tool life, D=depth of cut, F=feed rate, x and y are determined experimentally, n and C are constants found by experimentation or published data; they are properties of tool material, workpiece and feed rate (Kalpakjian and Schmid, 2006).

2.2 Cutting fluids application methods

The principal methods of cutting fluid application include:

a) Manual

b) Flood

c) Jet

d) Mist

(a) Manual application

Manual method is wiping with a rag soaked in a lubricant or brushing with a brush saturated in the lubricants remains a widely used method, minimizing capital costs for equipment. The method of this application is difficult to control. It is cost effective for short-run production and when control of lubricant thickness and location is not particularly critical (Kalpakjian and Schmid, 2006).

(b) Flood application

Flood application is the process where fluids are delivers to the cutting tool or workpiece interface by means of pipe, hose or nozzle system. The flood method is the most common method for applying cutting fluids in turning, drilling, and milling process. The flow rates can be as low as 10 l/min for turning and as 200 l/min for face milling. Chips can be washed away from the cutting region in deep- hole drilling and end milling by using fluid pressures ranging from 700 to14,000 kPa (Byers, 2006).

(c) Jet application

Jet application involves a high pressure and hence higher velocity jet of fluid being directed at the cutting zone. Again fluid drains into the sump in the base of the machine for filtering and delivery back to the nozzle. This form of application can be very effective in removing chips from the cutting area and may be particularly useful for higher cutting speed operation, including milling (Boothroyd and Knight, 1999).

(d) Mist application

Mist application is a method of lubricant application that has been particularly useful in machining, it involves the application of a fine mist through a spray orifice to the tool. Mist generators usually have filters for filtering the air and lubricant to be misted, pressure regulator, mixing valve, discharge nozzle, and a fluid reservoir. Air pressure between 10 to 80 psi (70 to 550kPa) is required, depending upon the desired particle size of the misted lubricant. Water-based fluids are particularly effective when misted. The large surface volume ratio of each liquid particle maximizes the possibility of rapid fluid vaporization. This situation will penetrate the active molecules at the tool-chip and tool-workpiece interfaces (Nachtman and Kalpakjian, 1985).

2.3 Drilling operation

Drilling is an important operation in manufacturing industry it is the process of producing round holes in solid materials or enlarging existing holes by the use of multi-tooth cutting tools such as drills, drill bits and inserts (Tolouei-Rad and Shah, 2012).

One estimate revealed that 75% of all metal-cutting material removed comes from drilling operations (Manikandanand Rajeswari,2003).This shows that drilling is the most common machining process.

Drilling involves the creation of holes that are right circular cylinders. This is accomplished most typically by using a twist drill, a cross section of a hole being cut by a common twist drill.The chips must exit through the flutes to the outside of the tool (Manikandanand Rajeswari,2003).The cutting elements of the drill are made of tool steel or cemented carbide. In the drilling process, three pairs of cutting edges (two main cutting edges, two margins and two halves of the chisel-edge) work together to make a hole (Tsao, 2007).

2.3.1 Metal Cutting Parameters

Conventional metal-cutting is the outwardly simple process of removing metal on a work piece in order to get a desired shape by relative movement of the work piece and tool, either by rotating the workpiece (as in a lathe) or by rotating the tool (as in a drilling machine) (Rassouli, 2011). Some parameters involved in the metal-cutting process are in fact closely related with some other parameters in the metal-cutting process; playing with one will have an influencing effect on another. These are the basic parameters of metal cutting processes (Rassouli, 2011).

i. **Material machinability:**

The machinability of a material decides how easy or difficult it is to cut. The material's hardness is one factor that has a strong influence on the machinability. Though a general statement like "a soft material is easier to cut than a harder material" is true to a large extent, it is not as simple as that. The ductility of a material also plays a huge role.

ii. Cutting tool material:

In metal-cutting, High Speed steel and Carbide are two major tool materials widely used. Ceramic tools and CBN (Cubic Boron Nitride) are the other tool materials used for machining very tough and hard materials. A tool's hardness, strength, wear resistance, and thermal stability are the characteristics that decide how fast the tool can cut efficiently on a job.

iii. Cutting speed and spindle speed:

Cutting speed is the relative speed at which the tool passes through the work material and removes metal. It is normally expressed in meters per minute (or feet per inch in British units). It has to do with the speed of rotation of the workpiece or the tool, as the case may be.

The higher the cutting speed, the better the productivity. For every work material and tool material component, there is always an ideal cutting speed available, and the tool manufacturers generally give the guidelines for it.

Spindle speed is expressed in RPM (revolutions per minute). It is derived based on thecutting speed and the work diameter cut (in case of turning/ boring) or tool diameter (in caseof drilling/ milling etc).

$N = V /(\pi \times D)$……………………………………………………………………………(2.3)

Where: V is the cutting speed, and

D is the diameter of drill.

iv. **Depth of cut:**

It indicates how much the tool digs into the component (in mm) to remove material in the current pass. The depth of cut in drilling is equal to one half of the drill diameter, this is expressed mathematically as:

$t = \frac{D}{2}$……………………………………………………………………………….. (2.4)

Where: D is the diameter of the drill

t is the is the depth of cut

v. **Feed rate:**

The relative speed at which the tool is linearly traversed over the workpiece to remove the material. In case of rotating tools with multiple cutting teeth (like a milling cutter), the feed rate is first reckoned in terms of “feed per tooth,” expressed in millimeters (mm/tooth). At the next stage, it is “feed per revolution” (mm/rev). In case of lathe operations, it is feed per revolution that states how much a tool advances in one revolution of workpiece. In case of milling, feed per revolution is the feed per tooth multiplied by the number of teeth in the cutter.

To calculate the time taken for cutting a job, it is “feed per minute” (in mm/min) that is useful. Feed per minute is the feed per revolution multiplied by RPM of the spindle.The feed of a drill is the distance the drill moves into the job at each revolution of the spindle. This can be expressed as feed per minutes, and this defined as the axial distance moved by the drill into the work per minutes. This is expressed mathematically as:

$$F = F_r \times N \qquad (2.5)$$

Where: F is Feed per minutes in mm

F_r is Feed per revolution in mm

N is the RPM (revolution per minutes) of the drill.

vi. Tool geometry:

For the tool to effectively dig into the component to remove material most efficiently without rubbing, the cutting tool tip is normally ground to different angles (known as rake angle, clearance angles, relief angle, approach angle, etc). The role played by these angles in a tool geometry is a vast subject in itself.

vii. Coolant:

To take away the heat produced in cutting and also to act as a lubricant in cutting to reduce tool wear, coolants are used in metal-cutting. Coolants can range from cutting oils, water-soluble oils, oil-water spray, and so on.

viii. Machine/ spindle power:

In the metal-cutting machine, adequate power should be available to provide the drives to the spindles and to provide feed movement to the tool to remove the material. The power required for cutting is based on the metal removal rate, the rate of metal removed in a given time, generally expressed in cubic centimeters per minute, which depends on work material, tool material, the cutting speed, depth of cut, and feed rate.

ix. Rigidity of machine:

The rigidity of the machine is based on the design and construction of the machine, the age and extent of usage of the machine, the types of bearings used, the type of construction of slide ways, and the type of drive provided to the slides. All play a role in the machining of components and getting the desired accuracy, finish, and speed of production.

Thus, in getting a component finished out of a metal-cutting machine at the best possible time within the desired levels of accuracy, tolerances, and surface finish, some or all the above parameters play their roles.

2.3.2 Processes involved in drilling operation

Drilled holes are characterized by their sharp edge on the entrance side and the presence of burrs on the exit side (unless they have been removed). Also, the inside of the hole usually has helical feed marks (Bralla, 1999).

When possible, drilled holes should be located perpendicular to the work piece surface; this minimizes the drill bit's tendency to "walk", that is, to be deflected, which causes the hole to be misplaced. The higher the length-to-diameter ratio of the drill bit, the higher the tendency to walk. The tendency to walk is also preempted in various other ways, which include:

a) Establishing a centering mark or feature before drilling, such as:

  i. Casting, molding, or forging a mark into the workpiece

  ii. Center punching

  iii. Spot drilling (i.e., center drilling)

b) Constraining the position of the drill bit using a drill jig with drill bushings.

Cutting fluid is commonly used to cool the drill bit, increase tool life, increase speeds and feeds, increase the surface finish, and aid in ejecting chips. Application of these fluids is usually done by flooding the workpiece or by applying a spray mist (Mattson, 2009).

2.3.3 Operations performed in drilling

The drill press is primarily meant for drilling operation, it can also be used for executing the following operations (Jain, 2009):

(a) Reaming (b) Boring (c) Counter- boring (d) Counter- sinking

(e) Spot facing (f) Tapping (g) Trepanning (h) Rivet spinning

(i) Polishing

2.3.4 Classification of Drilling Machine

Drilling machines are classified on the basis of their constructional features, or the type of work they can handle. The various types of drilling machines are (Singh 2006):

(a) Portable drilling machine

(b) Sensitive drilling machine ((*i*) Bench mounting and (*ii*) Floor mounting)

(c) Upright drilling machine ((*i*) Round column section and (*ii*) Box column section machine)

(d) Radial drilling machine ((*i*) Plain, (*ii*) Semi-universal, and (*iii*) Universal)

(e) Gang drilling machine

(f) Multiple spindle drilling machine

(h) Automatic drilling machine

(h) Deep hole drilling machine ((*i*) Vertical and (*ii*) Horizontal)

The commonly used drilling machines are described as under (Singh 2006).

a) Portable Drilling Machine

A portable drilling machine is a small compact unit and used for drilling holes in worpieces in any position, which cannot be drilled in a standard drilling machine. It may be used for drilling small diameter holes in large castings or weldments at that place itself where they are lying. Portable drilling machines are fitted with small electric motors, which may be driven by both A.C. and D.C. power supply. These drilling machines operate at fairly high speeds and accommodate drills up to 12 mm in diameter.

b) Sensitive Drilling Machine

It is a small machine used for drilling small holes in light jobs. In this drilling machine, the workpiece is mounted on the table and drill is fed into the work by purely hand control. High rotating speed of the drill and hand feed are the major features of sensitive drilling machine. As the operator senses the drilling action in the workpiece, at any instant, it is called sensitive drilling machine. A sensitive drilling machine consists of a horizontal table, a vertical column, a head supporting the motor and driving mechanism, and a vertical spindle. Drills of diameter from 1.5 to 15.5 mm can be rotated in the spindle of sensitive drilling machine. Depending on the mounting of base of the machine, it is classified into bench mounted drilling machine, andfloor mounted drilling machine.

c) Upright Drilling Machine

The upright drilling machine is larger and heavier than a sensitive drilling machine. It is designed for handling medium sized workpieces and is supplied with power feed arrangement.

In this machine a large number of spindle speeds and feeds may be available for drilling different types of work. Upright drilling machines are available in various sizes and with various drilling capacities. The table of the machine also has different types of adjustments. The two types of upright drilling machine are round column section and box column section. The round column section upright drilling machine consists of a round column whereas the upright drilling machine has box column section. The other constructional features of the two arethe same, Box column machines possess more machine strength and rigidity as compared to those having round section column.

d) Radial Drilling Machine

The radial drilling machine consists of a heavy, round vertical column supporting a horizontal arm that carries the drill head. Arm can be raised or lowered on the column and can also be swung around to any position over the work and can be locked in any position. The drill head containing mechanism for rotating and feeding the drill is mounted on a radial arm and can be moved horizontally on the guide-ways and clamped at any desired position. These adjustments of arm and drilling head permit the operator to locate the drill quickly over any point on the work. The table of radial drilling machine may also be rotated through 360 deg. The maximum size of hole that the machine can drill is not more than 50 mm. Powerful drive motors are geared directly into the head of the machine and a wide range of power feeds are available as well as sensitive and geared manual feeds. The radial drilling machine is used primarily for drilling medium to large and heavy workpieces. Three types of movement are provided for in plain radial drilling machine, these are, vertical movement of the arm on the column, horizontal movement of the drill head along the arm and circular movement of the arm in horizontal plane about the vertical column.

e) Gang Drilling Machine

In gang drilling machine, a number of single spindle drilling machine columns are placed side by side on a common base and have a common worktable. A series of operation may be performed on the job by shifting the work from one position to the other on the worktable. This type of machine is mainly used for production work.

f) Multiple-Spindle Drilling Machine

The multiple-spindle drilling machine is used to drill a number of holes in a job simultaneously and to reproduce the same pattern of holes in a number of identical pieces in a mass production work. This machine has several spindles and all the spindles holding drills are fed into the work simultaneously. Feeding motion is usually obtained by raising the worktable.

2.3.5 Drills

A drill is a multi-point cutting tool used to produce or enlarge a hole in the workpiece, it usually consists of two cutting edges. Broadly there are three types of drills, these are flat drill, straight-fluted drill, and twist drill. The cutting angle is usually 90 degree and the relief or clearance at the cutting edge is 3 to 8 degree. Twist drill is the most common type of drill in use today (Singh 2006). Twist drill comes in diameters ranging from about 0.15mm to as large as75 mm. Twist drills are widely used in industry to produce holes rapidly and economically(Groover 2010).Standard geometry of twist drill is shown in Plate I.

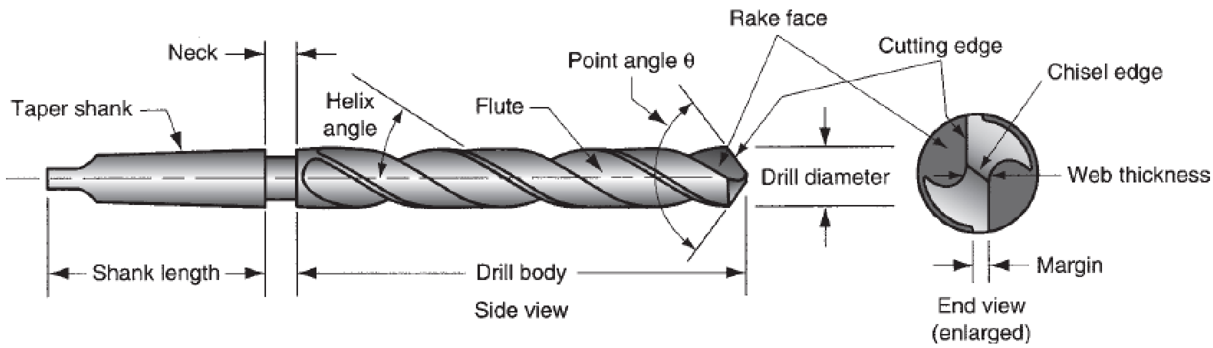

Plate I: Standard geometry of twist drill (Groover 2010).

The standard twist drill geometry as illustrated in Figure 2.1 as explained by Groover (2010)revealed that the body of the drill has two spiral flutes, the angle of the spiral flutes is called the helix angle, a typical value of which is around 30degree, when drilling is in process the flutes act as passageways for extraction of chips from the hole. Although it is desirable for the flute openings to be large to provide maximum clearance for the chips, the body of the drill must be supported over its length and the support is provided by the web, which is the thickness of the drill between the flutes.

The point of the twist drill has a conical shape, the typical value for the point angle is118degree. The point can be designed in various ways, but the most common design is a chisel edge, as in Figure 2.1. Connected to the chisel edge are two cutting edges, sometimescalled lips that lead into the flutes. The portion of each flute adjacent to the cutting edge acts as the rake face of the tool.

2.3.6 Effect of cutting fluids on drilling process.

Hole making had long been recognized as the most prominent machining process, requiring specialized techniques to achieve optimum cutting condition. Drilling can be described as a process where a multi-point tool is used to remove unwanted materials to produce a desired hole (Anil, 2012).

During the drilling process, the most important factor affecting the cutting tool performance and work piece properties is cutting temperature that emerges between drill bit and chip (Eyup and Babur, 2006).Heat is generated as a result of the work done in cutting metals. This heat reduces the hardness of the cutting tool makes it less wear resistant and changes its dimensions. Heat also leads to change in the dimensions of the machined surfaces. These temperature deformations of the tool and work reduce the machining accuracy (Braga, *et al.,* 2002).

Kuram (2009) investigated effects of developed vegetable based cutting fluids (VBCFs) and cutting parameters on thrust forces and surface roughnesses in the drilling of AISI 304 stainless steel. Ozcelik*et al.*, (2009) reported the effect of minimum cutting fluids (MCFs) developed from vegetable based cutting fluids (VBCFs) and other commercial MCFs on thrust force and surface roughness when drilling of AISI 304 stainless steel. In this study, the effect of cutting fluids developed from vegetable based oils would be evaluated for effectiveness on the tool wear and surface roughness during drilling of plain carbon steel.

2.4 Drilling Parameters

2.4.1 Cutting Speed: Cutting speed is the distance traveled by the work surface in unit time with reference to the cutting edge of the tool. The cutting speed, ***V***is simply referred to as speed and usually expressed in m/min(Kalpakjian and Schmid, 2006) as:

Cutting speed at drill outside diameter V=(π/12) *x (drill diameter) x (rpm).*

$V = (\pi \ D_d \ N_s)/12$…………………………………………………………… (2.7)

2.4.2 Feed: The feed is the distance advanced by the tool into or along the workpiece each time the tool point passes a certain position in its travel over the surface. In case of turning, feed is the distance that the tool advances in one revolution of the workpiece. Feed $f_m$is usually expressed in mm/rev. Sometimes it is also expressed in mm/min and is called feed rate.(Kalpakjian and Schmid, 2006) as:

Feed rate (rpm) = feed (ipr) x (rpm)

$f_m = f_r N_s$………………………………………..…………………… (2.8)

where: $N_s$is revolution of per minute of work or cutter and given as $N_s = 12V/(\pi D_d)$

and f_r is the feed per rev tooth pass (in/rev).

2.4.3 Depth of cut: It is the distance through which the cutting tool is plunged into the workpiece surface. Thus it is the distance measured perpendicularly between the machined surface and the unmachined (uncut) surface or the previously machined surface of the workpiece. The depth of cut ***d*** is expressed in mm (Kalpakjian and Schmid, 2006). Refer to its mathematical representation in equation 2.4

2.4.4 Material Removal Rate (**MRR**) in drilling is the volume of material removed by the drill per unit time. For a drill with a diameter ***D***, the cross-sectional area of the drilled hole is $\pi D^2/4$. The velocity of the drill perpendicular to the workpiece is the product of the feed f_r

and the rotational speed N where N = V /π D. (Kalpakjian and Schmid, 2006).

Material removal rate (in^3/min) = (π/4) *x (drill diameter) x feed rate (ipm)*

$$MRR = \frac{\pi D^2 L/4}{L/f_r N}$$

$$MRR = (\pi D^2/4)\ f_m \qquad (2.9)$$

2.4.5 Cutting Time: T_m is expressed as(Kalpakjian and Schmid, 2006) as:

$$T_m = L / f_m \qquad (2.10)$$

A conventional two flute drill with drill of diameter D, has two principal cutting edges rotating at an rpm of N and feeding axially. The rpm of the drill is established by the selected cutting velocity, V, where;

$$N_s = 12V/(\pi D_d) \qquad (2.11)$$

With V in surface feet per minute and D in inches (Braga, *et al.*, 2002).

This equation assumes that V is the cutting speed at the outer edges of the cutting lip. The feed, f_r, is given in inches per revolution. The depth of cut in drilling is equal to half the feed rate or $t = f_r/2$. The feed rate in inches per minute, f_m, is $f_r N$. The length of cut in drilling equals the depth of the hole, L, plus an allowance for approach and for the tip of drill, usually $A = D/2$.

Given a selected cutting speed and feed for drilling a hole in a certain metal with a drill of known tool material, the rpm of the spindle of the machine is determined from the equation below, the maximum velocity occurring at the extreme ends of the drill lips. The velocity is very small near the center of the chisel end of the drill.

For drilling, cutting time is given (Braga, *et al.*, 2002) as:

$$\text{Cutting Time} = \frac{(L + A)}{f_r N} = \frac{(L + A)}{f_m}$$

$T_m = L / f_m$……………………………………………………………… (2.12)

Where:T_m is cutting Time

L is Depth of the hole

A is the tip of the drill

$f_r$is Feed

f_m is Feed rate

N is the RPM (revolution per minutes) of the drill.

2.5 Methods of Extraction

The commonest methods used for extraction of oil from seeds and nuts are mechanical extraction, solvent extraction, traditional extraction and super critical fluid extraction.

2.5.1 Traditional extraction of seed oil

Traditionalmethod of oil extraction entails oil seed being subjected to thermal treatment, crushed and milled into slurry, water is then added to the slurry and the mixture stirred and kneaded by hand until the oil separates to the top and sides of the utensils being used for the kneading, The oil is carefully scooped from the surface of the water and boiled.This is the most usual way oil in being extracted and the process is called water floatation process (Aremu *et al.*, 2015). Traditional method can only be operable on a small scale and as such it is tedious and labour intensive as compared with other methods of extraction.

2.5.2 Mechanical Expression of Seed Oil

Mechanical expression of oils among the physical processes for the extraction of vegetable oils emerges as the best technology to serve small farmers. This is because this type of equipment associates both small scale and low cost when compared to the other methods. Another important advantage is the possibility of using cake resulting from the pressing as fertilizer or animal feed, since it is free of toxic solvents (Bachmann, 2004).

Mechanical oil extraction is achieved either in two stages (size reduction to produce pulp or slurry, followed by separation in a press) or in a single stage, which both rupture the cells and express the oil. In general, the single-stage operation is more economical, permits higher outputs and has lower capital and operational cost but not suitable for hard nuts as the two stage of expression is more effective. The degree of effectiveness varies with the kind of oilseed and method of oil expression (Akinoso, 2006).

2.5.3 Solvent extraction of seed oil

Solvent extraction is the use of chemicals as solvents in the extraction of oil from oilseeds. Solvent extraction is known for its high yielding oil output, ease and swiftness to carry out; relatively cost effective, high overhead cost, and hazardous effects during and after operations. The use of this method requires a complete refining process to ensure traces of the solvents are removed totally. Solvent extraction of cleaned, cracked, dehulled and conditioned thin soy flakes (0.25–0.30 mm) with hexane is commercially practiced to extract oil (Becker, 1978, Galloway, 1976). Commercial solvent extraction does not include any pre-pressing operation due to the relative disadvantages of low oil content and slower oil recoveries. Becker (1978), Johnson and Lusas (1983) indicated that hexane, apetroleum-derived product has been extensively used as solvent for the oil extraction of soya beans and other oilseeds because of its low vapourisation temperature(boiling point 63 – 69oC), high stability, low corrosiveness, low greasy residual effect, and better aroma and flavour productivity for the milled products. However hexane is occasionally scarce and its price fluctuates depending on the supply and demand for gasoline (Johnson and Lusas, 1983). Narain and Singh (1988) also reported that the use of hexane in small-capacity plants makes the processing expensive due to high operational losses.

2.6 Descriptions of Vegetable plants under investigations

2.6.1 Water melon seeds

Watermelon is a drought tolerant crop which belongs to the *cucurbitaceae* family of flowering plants. It is generally considered to be of the *citrullus* species and has been referred to as *citrullus vulgaris*(Naseri and Tehrani 1995).Watermelon is originally found in southern Africa and reaches maximum inherited diversity there, with sweet, bland and bitter forms (Dane and Liu 2007).

2.6.2 Neem seeds

Neem (Azadirachta indica) which belongs to the family Meliaceae, originated from South Asia, but grows widely in India, Pakistan and other tropical and sub-tropical parts of the world (Bokhari and Aslam, 1985;Von Maydell, 1986). The tree was introduced in Nigeria from Ghana, and it was first grown from the seeds in Maiduguri, in the then Bornu Province, Nigeria, in 1928 (National Research Council, 1992; Nwoeabia, 1994).

2.6.3 Tiger nuts

Tiger-nut (*Cyperus esculentus L.)* belongs to the Division–*Magnoliophyta*, Class–*Liliopsida*, Order–*cyperales* and Family–*Cyperaceae* and was found to be a cosmopolitan, perennial crop of the same genus as the papyrus plant. The tubers are about the size of peanuts and are abundantly produced in Nigeria. Other names of the plant are earth almond as well as yellow nut grass. In Nigeria, the Hausas call it Aya, Yorubas imumu, the igbos ofio, aki Hausa in southern Nigeria (Osagie and Eka, 1998).

2.7 Review of Past Works

Nyior (1994) investigated the performance of some vegetable oils (Palm, groundnut, Soybean and shea butter oils) as lubricants for cold extrusion of Aladja ST 60-02 structural steel and found out that they all performed better than the standard zinc phosphate/sodium stearate lubricant.

Obi and Oyinlola (1996) investigated the frictional characteristics of Palm and shea butter oils in wire drawing operation. They observed that Palm oil performed better than the standard sodium stearate drawing lubricant. They also established that physicochemical properties of these oils (especially iodine and fatty acid values) enhanced their performance and that large amount of lubricating agents such as Palmitic and oleic acids were reported to give better performance advantages in wire drawing.

Obi (2000) evaluated the lubricity assessments of vegetable based oils in some metal forming processes. He concluded that out the characteristic curves for the experimental lubricants were very distinct showing that their performances varied in the order of groundnut oil, Palm kernel oil, Palm oil and shea-butter in respect to tool wear measurement, surface roughness and chip rate formation.

Belluco and De Chiffre (2001) investigated effect of vegetable based cutting oil on cutting forces and power. AISI 316L staisheanless steel workpieces were machined with drilling, core drilling, reaming and tapping using HSS-E tools. A comparison of performance results obtained from two cutting fluids showed that the vegetable based cutting oils were better than the commercial mineral oil.

Belluco and De Chiffre (2004) evaluated the performance of six cutting fluids (a commercial mineral oil, and five vegetable-based cutting fluids) in drilling AISI 316L stainless steel using conventional HSS-Co tools. Tool life, tool wear, chip formation and cutting forces were studied as performance criteria and results were better with vegetable cutting oil than that of the mineral cutting fluid because tool life was increased by 177% and thrust force was reduced by 7%.

Xavior (2009) studied performance of coconut oil during the machining of AISI 304 material with carbide tool. They found that Coconut oil reduced the tool wear and improved the surface finish with respect to mineral oil.

Gaminana (2011) investigated the evaluation of some vegetable oils (Neem, Tigernut and false walnut) as metal working lubricants for industrial application and at the end, found out that they were all suitable for cold rolling of aluminum. He also concluded that false walnut was evaluated to be the most suitable of the oils for both cold rolling of aluminum and drawing of steel.

CHAPTER THREE

3.0 MATERIALS, EQUIPMENT AND EXPERIMENTAL PROCEDURE

3.1 Introduction

This chapter outlines the various materials and equipmentused for this research as well as the methods employed in carrying out the research.

3.2 Materials

The work piece was a mild steel sourced from metal scrap market "Pantaker" in Kaduna. The chemical composition analysis was carried out at Defense Industries Cooperation of Nigeria (DICON) with Optical Emission Spectrometer.

The cutting fluids are conventional mineral oil and the selected plant oils, the mineral oil is under the trade name 'Mobilcut102' product of Exxon Mobil Corporation. Mobilcut102 is designed to be mixed with water at concentrations in a range of 1:10 to 1:20 parts oil to water for light and medium duty machining (www.mobil.com, 2015). The typical properties of this conventional oil as stated by the manufacturer are shown in Table 3.1

Table 3.1

Mobilcut 102

Colour, ASTM	Density, @15°C (kg/L)	Emulsion Stability	Pour Point (neat), °C	Viscosity (neat) @40°C
2	0.89	Excellent	-6	34

Source:www.mobil.com, (2015).

The tiger nut and water melon seed were obtained from Ungwanrimi market in Kaduna while the neem seed was sourced from National Research Institute for Chemical Technology (NARICT) Zaria. The extraction and analysis of oils from the three oil seeds were carried out at National Research Institute for Chemical Technology (NARICT) Zaria.

3.3 Equipment

Equipment used in carrying out the entire research includes:

1. Vertical Drilling machine
   Brand/Model: Chofum Column drilling Machine No.5226
   Spindle Speed: 80-1400 rpm
   Feeds: 0.05-0.30mm/rev
   Location: Department of mechanical engineering, ABU, Zaria.

2. Infrared Thermometer
   Brand/ Model: BENETECH GM320
   Measuring Range: -30^{0}C to 500^{0}C
   Accuracy: +-1.5^{0}C/+-1.5%
   Optical Resolution: 0.1^{0}C
   Emissivity: Fixed 0.95

   Location: Procured

3. Optical Emission Spectrometer
   Brand: OES 7000
   Make: Shimadzo
   Location: Defence Industries Cooperation of Nigeria (DICON), Kaduna.

4. Surface Roughness Tester
   Model: Dualscope Fischer device
   Location: Quality control section of Peugeot Automobile Nigeria (PAN), Kaduna.

5. Digital Rotary Viscometer
   Model: NDJ-8S, England
   Location: National Research Institute for Chemical Technology (NARICT) Zaria.

6. Micrometer screw gauge
   Brand/ Model: More and Wright NO 712
   Range: 0.6 to 1.0 pitch.
   Location: Department of mechanical engineering, ABU, Zaria.

7. High Speed Steel (HSS) drill tool bit of 20 mm diameter and 120 mm in length.
   Obtained from Department of mechanical engineering, ABU, Zaria.

8. Hammer, mallet, Center punch and Knockout punch kit.
   Obtained from Department of mechanical engineering, ABU, Zaria.

3.4 Experimental Procedures

3.4.1 Process for Extracting Vegetable oils

The continuous mechanical pressing or screw press was used for the extraction, the collected seeds were first cleaned by removal of foreign materials such as ticks, stains, leaves, sands and dirt. The extraction process commences by putting the seeds inside the feed hopper. The movement of helical screw forced the oilseed mass through the barrel by the action of the revolving warms. This mass was being reduced as the transition takes place through the barrel, causing compression of the cake, spacers which are placed between the lining bars allows the drainage of oil as the pressure over the grains is increased, and the cake is discharged through the orifice while the resulting oil was expelled through the perforated lining bars of the barrels. This system is being powered with electric motor, the mechanical pressing system is shown in plate II. However residual oil were extracted from the cake by cold pressing method using a manually operated equipment as shown in plate III

PlateII: Continuous Mechanical Screw pressing Machine.(NARICT, Zaria)

Plate III: Cold Screw Pressing Set up (NARICT, Zaria)

The extracts were filtered at the end of the extraction period, stored in a clean bottle and covered properly. The three vegetable oil were subjected through these processes, the oil samples are shown in Plate IV, the entire extraction processes were carried out at National Research Institute for Chemical Technology (NARICT), Zaria.

PlateIV: Samples of Vegetable cutting fluids (NARICT, Zaria)

3.4.2 Preparation of conventional soluble oil 'Mobilcut 102'

Soluble oil was prepared for used by mixing the mobilcut 102 with water at a designed rangeof 1:20 parts oil to water as directed by the manufacturer. One part oil is stirred into twentyparts water, the desired ratio was achieved using measuring cylinder. The Physiochemical properties of this mineral oil (mobilcut 102) after being diluted with water at ratio 1:20 parts oil to water are given in table 4.2

3.4.3 Physiochemical analysis of the oils

The physicochemical analysis of oils which includes relative density, refractive index, saponification value, peroxide value, acid value, iodine value and viscosity were carried out according to AOAC (2002), AOCS(1992) and the standard methods were used for the determination of oils properties at National Research Institute for Chemical Technology (NARICT) Zaria. The various results for the physiochemical analysis of all the cutting fluids under observation are tabulated in table 4.2

3.4.3.1 Percentage Yield

Percentage Yield: The percentage (%) yield of each of the oil sample is the ratio of the weight of extracted oil to the weight of the cake after extraction. The mathematical representation is given in equation 3.1

$$\text{Percentage yield of oil} = \frac{\text{Weight of the oil}}{\text{Weight (g) of sample}} \times 100$$

$$\text{Percentage yield of oil} = \frac{W1-W2}{W2} \text{ X } 100 \ldots\ldots (3.1)$$

where W1= Weight of sample before extraction and

W2 = Weight of cake after extraction.

The percentage yield of all the vegetable oils are given in Table 4.3

3.4.3.2 Refractive Index

Refractive index: Abbey refractometer was used in determining the refractive index of each of the oil sample. The measuring prism surface was cleaned with solvent and distilled water, and then wiped with a clean towel after which the mode selector was regulated to the desired mode position. A drop of oil was dropped on the prism surface using a glass dropper and covered. The illumination arm was then positioned so that the exposed face of the upper prism will be fully illuminated. The refractometer was used through the eyepiece, the dark position viewed was adjusted to be in line with the cross line. At no parallax error, the pointer to the scale pointed in the refractive index, the reading was then taken. This measurement represents the refractive index of the oil sample.

3.4.3.3 Relative Density

Relative Density: A clean and dry relative density bottle was weighed (M1).The bottle was filled with distilled water and gentle covered with the lid, the outside walls of the bottle was cleaned and weighed (M2). The same procedure was conducted for each of the oil and relative density is calculated thus:

$$\text{Relative density (R.D.)} = \frac{(M1 - M2)\ \text{oil}}{(M2 - M1)\ \text{water}} \quad \ldots\ldots (3.2)$$

3.4.3.4 Acid Value

Acid Value: A 50ml (1:1) solvent minute of diethyl ether and ethanol was measured into an erlenmeyer flask and 2g of oil was added and shacked. To the solution 1% phenolphthalein solution was added and titrated with 0.1m potassium hydroxide solution.

$$\text{Acid Value} = \frac{\text{weight of sample}}{\text{Titration (ml)} X 5.61} \quad \ldots\ldots (3.3)$$

3.4.3.5 Saponification Value

Saponification Value (SV): The saponification value(SV) of each of theoil samples were determined following procedures described in AOCS method (AOCS, 1992). Oil sample (1 g) was dissolved in 12.5 ml of0.5 N ethanolic potassium hydroxide. The mixture was refluxed for 30 minutes until oil droplets disappear and was left to cool to room temperature. Phenolphthalein indicator was then added and the hot soap solution was titrated with 0.5 N HCl until the pink colour disappears. A blank titration was also carried out in the same manner except that no oil was added. Saponification value was calculated using the formula:

$$\text{Saponification Value (SV)} = 56.1\frac{(a - b) \times N}{W} \quad \ldots\ldots (3.4)$$

Where;

a = Volume (ml) of 0.5 mol/l hydrochloric acid consumed in the blank test,

b = Volume (ml) of 0.5 mol/l hydrochloric acid consumed in the test,

N = Normality of hydrochloric acid,

W = Weight of oil sample, g.

3.4.3.6 Iodine Value

Iodine Value (IV): 0.1g sample of oil was delivered to a 300 mL conical flask with ground-in stopper and mixed with 20.0mL carbon tetrachloride and sealed. It was dissolved in an ultrasonic washing machine. 25.0mL Hanus solution was added and sealed. It was shook for one minute, kept sealed and left in a dark room (about 20°C) for 30 minutes. 10.0mL of 15% potassium iodide and 100 mL water were added, sealed and shook for 30 seconds. The mixture was titrated with 0.1mol/L sodium thiosulfate to obtain iodine value. Likewise, blank test was performed to obtain blank level (AOCS, 1992).

$$\text{Iodine Value (IV)} = \frac{127\,(a-b) \times N}{10W} \quad \ldots\ldots (3.5)$$

Where;

a =Volume (ml) of 0.1 mol/l sodium thiosulfate consumed in the blank test,

b = Volume (ml) of 0.5 mol/l sodium thiosulfate consumed in the test,

N = Normality of sodium thiosulfate,

W = Weight of sample.

Iodine Number : Number of iodine (g) absorbed by 100 g of oil.

3.4.3.7 Peroxide Value

Peroxide Values (PV): The Peroxide values (PV) of oil samples were determined according to AOCS method(AOCS, 1992). Oil sample (5 g) was weighed into a200 ml conical flask and mixed with 300 ml of glacial acetic acid and chloroform (3:1) and mixed thoroughly by swirling the flask. Saturated potassium iodide (0.5 ml) was then added and the mixture was left in the dark for 1 minute with occasional swirling, followed with further addition of 30 ml distilled water. The mixture was titrated with 0.1 N sodium thiosulphate solution with 1 ml of 1.0 % soluble starch as indicator until the blue colour disappears. A blank sample titration was also carried out in the same manner but with no oil added.

$$\text{Peroxide Value (PV)} = \frac{(a - b) \times 10}{W} \quad \ldots\ldots (3.6)$$

Where;

a =Volume (ml) of 0.1 mol/l sodium thiosulfate consumed in the blank test,

b = Volume (ml) of 0.1 mol/l sodium thiosulfate consumed in the test.

W = Weight of the sample (g).

3.4.3.8 Viscosity

Viscosity: The viscosity of each oils were measured using digital rotary viscometer following these processes, 100ml sample of oil to be measured was put inside a glass beaker, the lifting screw was adjusted and the rotor was put inside a measured liquid till the level marked on the rotor reached the liquid surface.The power switch was turn on at the control panel to rotate the rotor at a speed of 60 rpm. The rotor which was subjected to a torque moment proportional to liquid viscosity due to liquid viscose hysteresis. The torque moment was measured by the sensors and processed it to the viscosity in mPa.s, temperature in degree centigrade and percentages, all these were displayed at the control panel. This process was repeated for all the cutting fluids under investigation. Plate V shows digital rotary viscometer.

Plate V: NDJ-8S Digital RotaryViscometer (NARICT, Zaria)

3.4.4 Chemical composition of metal using Optical Emission Spectrometer

The chemical composition analysis of mild steel was carried outat Defense Industries Cooperation of Nigeria (DICON), Kaduna using Shimadzu optical emission spectrometer, the procedure was as follows. The electrical energy was imparted unto a metal sample and the vaporized atoms were excited to obtain emission spectra which were unique to the elements. These emission spectra were separated by a monochromator and a detector (photomultiplier tube) detects the presence and intensity of each for quantification and qualification of the elements contained in the sample. This analysis obtained quantitative values for several elements within one minute of starting analysis. The chemical composition of the workpiece is given in Table 4.1.

3.4.5 Procedure for drilling operation

The Mild Steel sample with length 1000mm was cut into 20 pieces with power hacksaw, each of the pieces was 40mm long and 40mm in diameter respectively. The cut out pieces are shown in plate VI. The drilling operation was carried out on a floor mounted vertical column drilling machine, Chofum make, the machine is shown in plate VII. High Speed steel (HSS) tool of 20mm diameter was adapted firmly in the spindle of the drilling machine. Each sample of the work piece was center punched before mounting on the vice to forestall instability of the cutting tool on the work piece material, thereby making the work piece firmly secured for drilling and the rigidity of the entire system guaranteed.

PlateVI: 20piecesof mild steel, each 40mmX Ɵ40mm

Plate VII: Vertical Drilling machine (Chofum make)

The oil was applied manually with rubber bottle by flooding method at a predetermined flow rate of approximately 5.0 ml/s. The application of the oil was continuous from inception of the drilling to when the sample steel was bore through. The chip/tool interphase was seen to be adequately wet with the cutting fluid by the rubber bottle which was directed to the cutting zone.The flow rates of the three selected plant oil were approximatelythe same because their viscosities were very close.The viscosity of the plant oils are given in the table 4.2.

The chips produced under specified drilling parameters of varying spindle speed, feed rates and constant depth of cut for various cutting fluids and dry drilling environment were measured with micrometer screw gauge, three chips per each sample of drilled piece were measured and the average was taken as the required chip thickness for a particular sample piece. The chip thickness is given in Table 2 at the appendix.

The temperature generated at the interface of the chip/ tool zone were taken with a gun type infrared thermometer held approximately 600mm away from the cutting environment. The precise chip/tool spot temperature measurement was achieved with the incorporated laser ray which aids in focusing.The gun type Benetech GM320 Infrared thermometer is shown in plate VIII.

PlateVIII: Benetech GM320 Infrared Thermometer.

The various measured temperature generated are given in Table 1. The time taken for the workpiece to be drilled through was measured with digital clock. These valuesare also given in Table 1.

The entire processes were repeated for various oils under investigation and dry drilling environment, while observing basic machining operational principle at every moment of drilling. Plate IX, X, XI and XIIshows the application of various cutting fluids and dry drilling condition while temperature generated is being measured with Infrared thermometer during drilling operation of mild steel. The drilling operation was carried out at Department of Mechanical Engineering Central Workshop,Ahmadu Bello University, Zaria.

 

Plate IX:Application ofwater melon oil   Plate X: Application of solubleoil as
asCutting fluid in drilling operation of mild   Cutting fluid in drilling operationof mild steel
while measuring the temperature   steel while measuring thetemperature generated with
InfraredThermometer. generated with Infrared Thermometer.

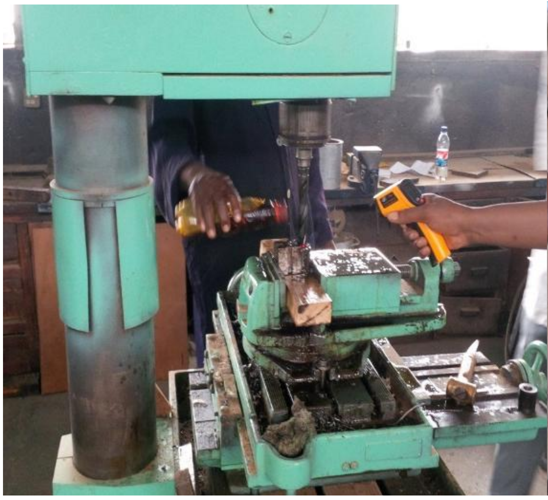

Plate XI: Application of neem seed oil as Cutting fluid in drilling operation of mild steel while measuring the temperature Thermometer.generated with Infrared Thermometer.

Plate XII: Dry drilling operation of mild steel while measuring the temperature generated with Infrared

3.4.6 Surface Roughness Measurement

The evaluation of the effects of surface roughness on all the oil samples under investigations and dry drilling condition were determined by cutting the drilled samples longitudinally into two parts,thereby allowing the proper measurement of surface roughness using the probe to touch the drilled surface. Refer to Figures 3.1and plate VIII for the sketches and pictorial of different stages of workpiece development.

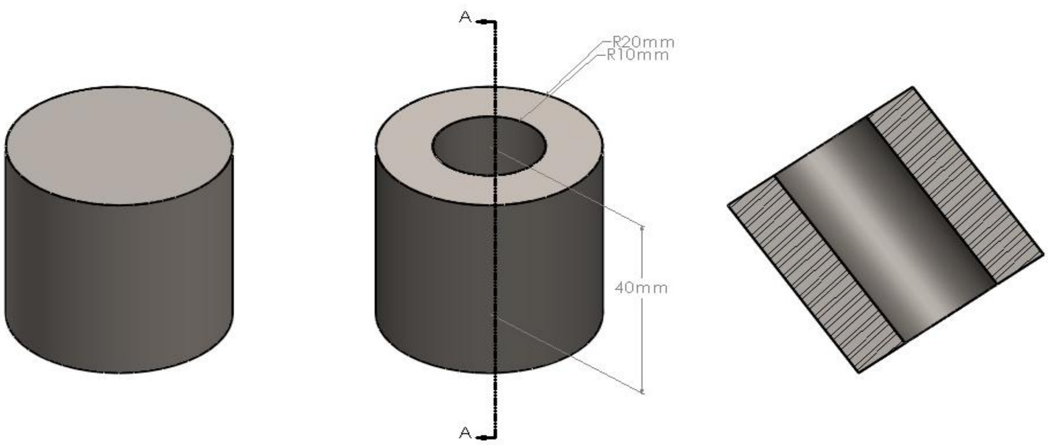

Figure. 3.1: Sketches of different stages of workpiece development.

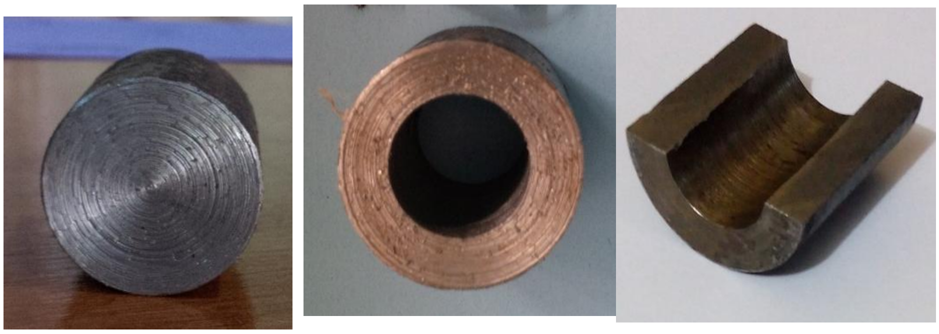

Plate. XIII: Pictorial view of different stages of workpiece development

The DualscopeFMPFischer device was equipped with a magnetic induction measurement probe with the rangeof 0 to 2000µm.Information and values of surface irregularities was taken from the digital meter. This exercise was repeated thrice for each half piece of the sample size on three different spots, average of which was taken as the surface roughness value. This operation was carried out in Quality control section of Peugeot Automobile Nigeria (PAN) in Kaduna, Kaduna State. Plate XIV shows the process of typical surface roughness measurement with roughness value indicated on the digital meter. The values of various roughness obtained are as shown in Table 3 at the appendix.

PlateXIV: Measurement of Surface Roughness of drilled part of work piece using Dualscope Fischer device.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Introduction

4.2 Result

This chapter present the results of chemical composition of workpiece material,Physico-chemical analysis of the oil samples, The percentage oil yield for the vegetable oils, graphical representation of temperature with specified spindle speed, chip thickness with specified spindle speed, surface roughness with specified spindle speed and surface roughness with feed rate respectively for all the various cutting fluids and dry drilling environment.

4.2.1 Chemical composition of workpiece material: Mild steel sample

The result of Optical Emission Spectrometer (OES) analysis carried out on mild steel sample is shown in Table 4.1 below

Table 4.1: Chemical composition of workpiece material: Mild steel

Element	C	P	Cr	Si	Mn	Mo
% Composition	0.2421	0.0049	0.0105	0.2020	0.7374	0.0011
Element	S	Ni	V	W	Co	Zn
% Composition	0.0107	0.1067	0.0005	0.0065	0.0004	0.0017
Element	As	Al	Cu	Sn	Pb	Fe
% Composition	0.0006	0.0013	0.0036	0.0022	0.0005	97.6822

4.2.2 Physico-Chemical properties of Cutting Fluids under Evaluation.

Table 4.2 presents the result of physico-chemical properties of cutting fluids under evaluation.

Table 4.2: Physico-Chemical properties of Cutting Fluids under evaluation.

S/N	Samples	Relative Density	Refract-ive Index	Saponific-ation Value	Peroxide Value	Acid Value	Iodine Value	Viscosity @60 rpm
1	Tiger Nut oil	0.9015	1.4644	186.5	1.29	3.478	111.04	499.3 @27.6ºC
2	Neem Seed oil	0.9447	1.4738	217.4	1.46	7.433	107.86	499.0 @27.5ºC
3	Water Melon seed oil	0.9181	1.4706	200.5	0.42	3.254	142.13	504.3 @27.5ºC
4	Conventional oil	0.9210	1.2523	190.5	0.33	5.642	132.24	52.5@27.5ºC

4.2.3 Percentage yield of the Vegetable oil

Table 4.3 presents the Percentage yield of the three oil samples

Table 4.3: Percentage yield of the three oil samples

	Samples of Vegetable plant	Weight of Vegetable seed before Extraction (W_1) in gram	Weight of cake after extraction (W_2) in gram	Weight of oil Extracted (W_1-W_2) in gram	Percentage yield (%)
1	Neem Seed oil	2000	1270	730	57.4
2	Tiger Nut oil	2300	1680	620	36.9
3	Water Melon Seed oil	2150	1500	650	43.3

4.2.4 Graphical representations of the results

Figure 4.1 show the plot of temperature with specified spindle speed, whilethe plot of chip thickness with specified spindle speed is shown in Figure 4.2, Figure 4.3and 4.4 depictsthe graph of surface roughness with specified spindle speed and feed rate respectively for all the various cutting fluids and dry drilling environment. Figure 4.5 show the graph of Percentage yield of the vegetable seeds.

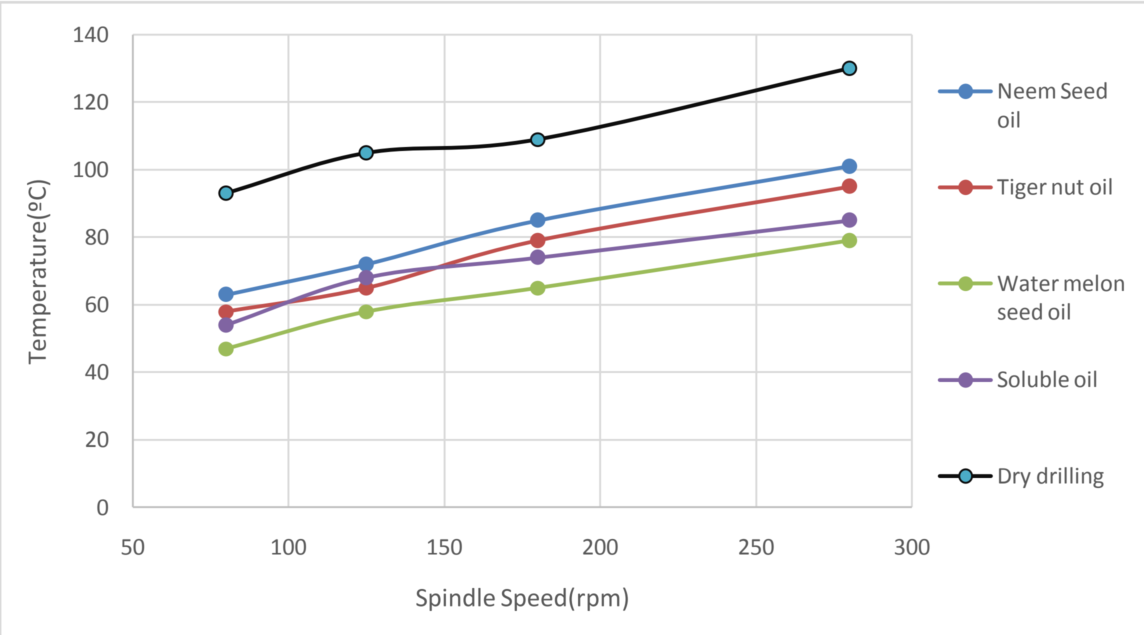

Figure 4.1: Variation ofspindle speed with temperature for various cutting fluids and dry drilling environment.

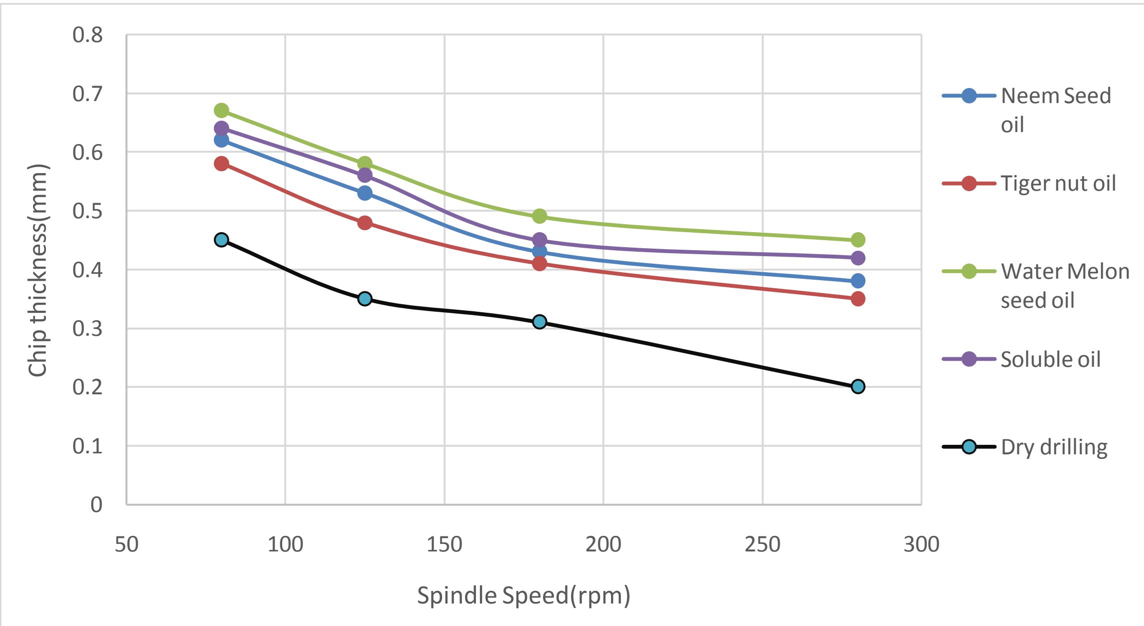

Figure 4.2: Variation of spindle speed with chip thickness for various cutting fluids and dry drilling environment.

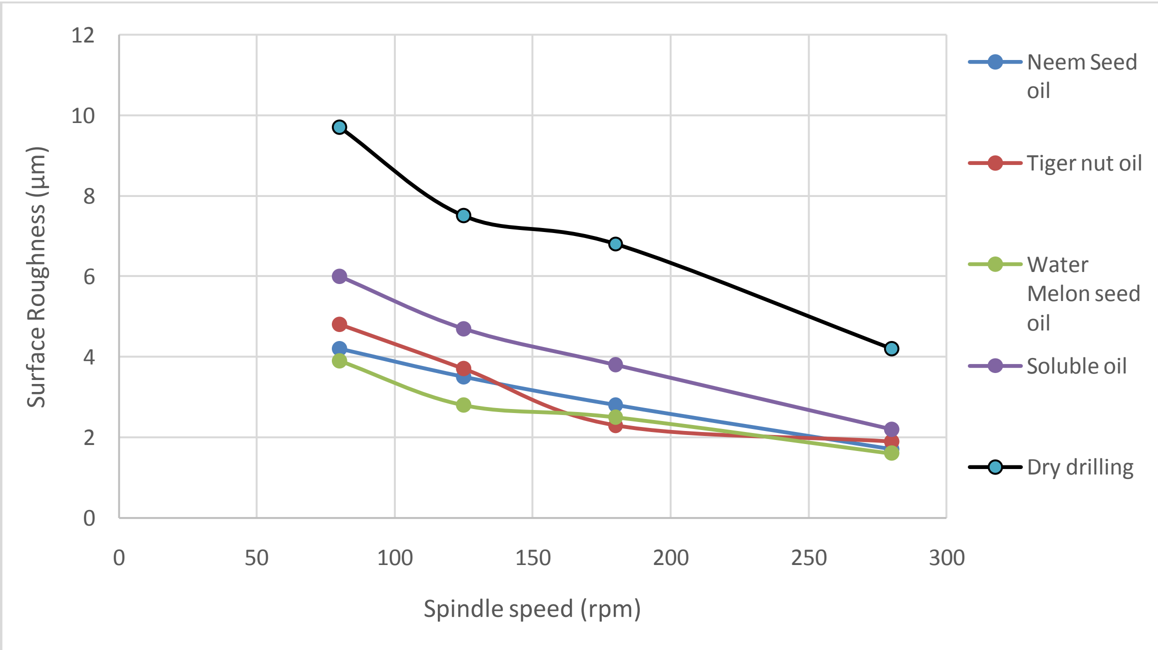

Figure 4.3: Variation of spindle speed with surface roughness for various cutting fluidsand dry drilling environment.

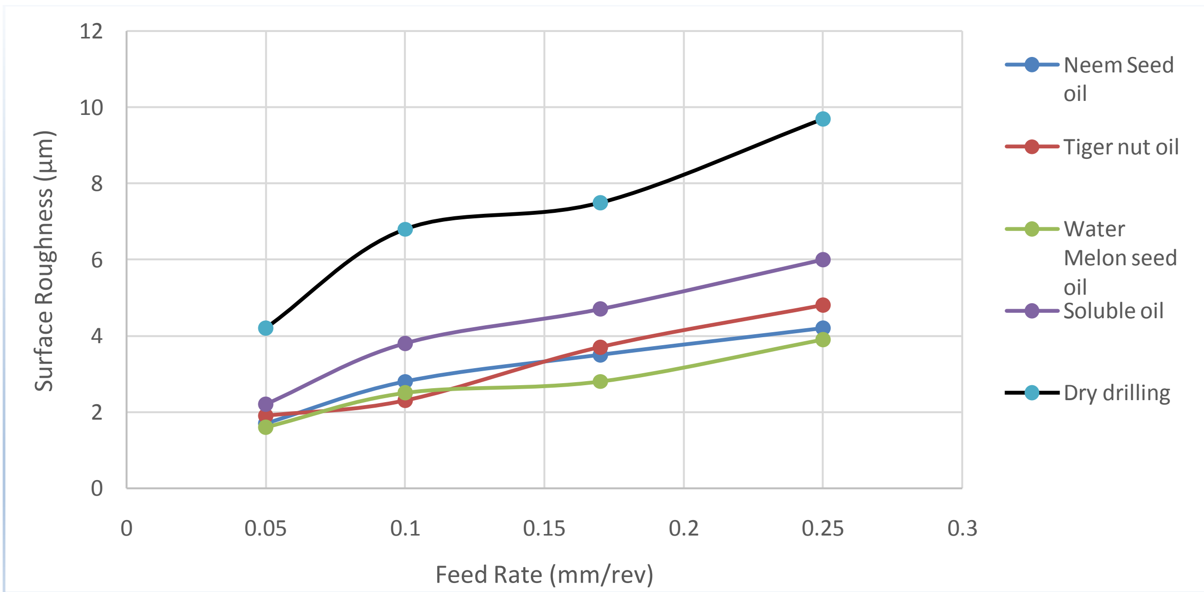

Figure 4.4: Variation of feed rate with surface roughness for various cutting fluidsand dry drilling environment.

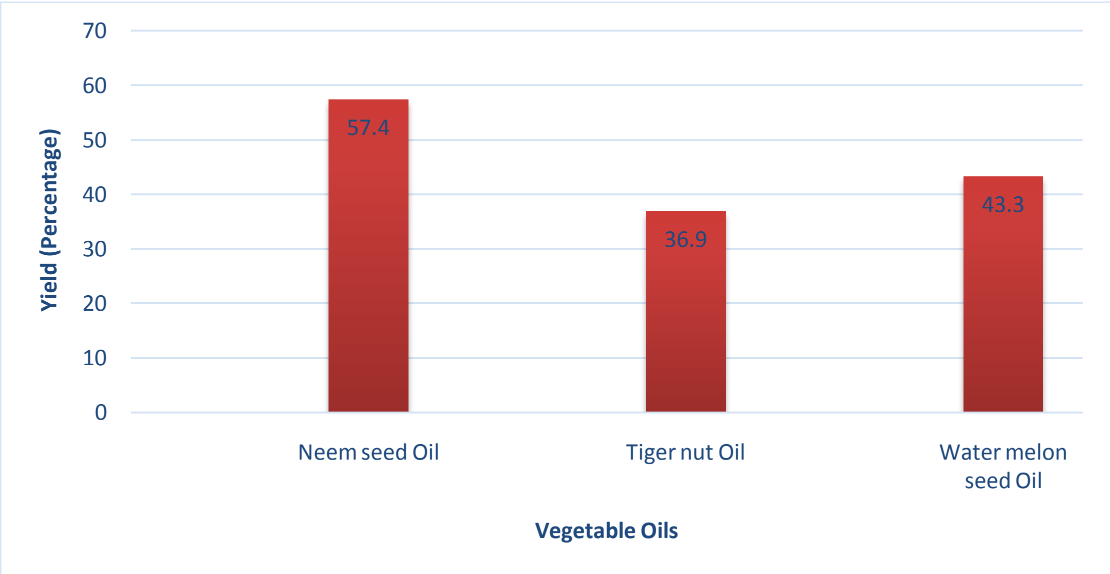

Figure 4.5: Percentage yield of Vegetable seeds under evaluation

S/N	**Cutting Fluids**	80 rpm	125 rpm	180 rpm	280 rpm
1	Neem Seed oil				
		Short segmented conical chip.	Segmented conical chip.	Long continuous conical chip	Long continuous serrated chip
2	Tiger Nut oil				
		Short segmented curl chip.	Short segmented curl chip.	Segmented curl chip.	Long continuous conical chip

3	Water Melon Seed oil				
		Short segmented curl chip.	Short segmented curl chip.	Segmented curl chip.	Short continuous conical chip
4	Soluble oil				
		Short segmented curl chip.	Short segmented curl chip.	Short segmented curl chip.	Short continuous conical chip
5	Dry drilling				
		Short segmented burnt chip.	Long continuous burnt conical chip.	Long continuous burnt spiral chip	Long continuous burnt serrated chip

Plate XV:Variation of chip formation characteristics with specified Cutting speed for all the Cutting Fluids and dry drilling environment.

4.3 Discussion of Results

4.3.1 Variation of spindle speed with temperature for various cutting fluids and dry drilling environment.

Figure 4.1shows that increase in spindle speed increases the temperature generated irrespective of the cutting fluid, this result was in consistent with the submission of (Vaibhav, *et al., 2012*).Dry drilling was having thehighest temperature generated among all, this is in agreement with Jamiu and Sharafadeen (2013), who established that high temperature in dry machining was due tohigh friction between the tool and workpiece.Hassan *et al,* (2006) also posited that the contact pressure between devices in close proximity which are moving relative to each other are usually sufficient to cause surface wearing, frictions and generation of excessive heat without protector. However with various cutting fluids under investigation their cooling performances are different, water melon seed oil exhibit the lowest temperature generated follow by soluble oil, neem seed oil and tiger nut oil respectively. The performance of selected plant cutting fluid are very similar becauseof their close viscosity value.

4.3.2 Variation of spindle speed with chip thickness for various cutting fluids and dry drilling environment.

Figure 4.2 shows that increase in spindle speed decreased the chip thickness value for all the cutting fluids and dry drilling inclusive, it is evident from the table 2. That average thickness of chips value produced at lower spindle speeds are greater than those obtained at higher spindle speed. This is a desirous phenomenon because high value of chip thickness translate to better rate of metal removal which entails completing the machining at a lesser time (Krahenbuhl, 2002). It is worthy of note that water melon seed oil was having highest value of average chip thickness of 0.67mm at lowest value of spindle speed of 80rpm. Lowest value of average chip thickness of 0.20mm at highest value of 280rpm spindle speed was obtained in dry drilling condition, this may be due to ease of fracturing as a result of striking of the chips with the workpieceas established by Jamiu and Sharafadeen (2013). This would be accompanied by high frictional effect between the workpiece and the cutting tool.

4.3.3 Variation of spindle speed with surface roughness for various cutting fluids and dry drilling environment.

Figure 4.3 shows that increase in spindle speed decreased the surface roughness value. (Kuram*et al.,* 2010) attributed this phenomenon to the fact that high spindle speed reduces the forces and vibration, giving better surface finish. This result was in consistent with (Tsao, 2007) and (Davim*et al.,* 2006).The least surface roughness was achieved at spindle speed of 280 rpm using water melon seed oil. There is considerable difference in the value of surface roughness of dry condition and flood condition of various cutting fluid, highest surface roughness was recorded with dry drilling condition at spindle speed of 80 rpm. Better surface finish were recorded with the three selected plant cutting fluids having very close surface roughness value, this can be attributed to their close viscosity values. Thus viscosity value as explained by HongandBroomer (2000), denotes the ability of the cutting fluid to prevent metal to metal (wear) contact, while low value may determine its ability for heat dissipation. In similar tone Salate and Joao (2008), reported that high lubricating ability is a direct function of high viscosity.

4.3.4 Variation of feed rate with surface roughness for various cutting fluids and dry drilling environment.

Figure 4.4 shows that increase in feed rate increased the surface roughness value, since increase in feed rate increased material removal rate as corroborated byPrasanna*et al*., (2014) that,at higher feed rate tool travels rapidly which lead to less cycle time as well as sufficient cooling at tool and chip interface thereby reducing the heat and easily remove the chips at cutting area which results to increase material removal rate with less time. Narinder, *et al.*, (2014) also expressed in similar statement thatconsistent increase of feed rate, leads to increased surface roughness, because due to increase of push force on tool in the work-piece eventually results into the more material removal rate from the work-piece surface as well as produces vibrations in tool leads to enhance surface roughness. The increase in feed rate which results to increase in surface roughness value was consistent withthe submission ofDavim *et al*.,(2006), Tsao(2007) and Basavarajappa, *et al*., (2008).The least surface roughness of 1.6μm was recorded with water melon seed oil at 0.05 mm/rev while the highest value of 9.7μm was recorded with dry drilling condition at 0.25mm/rev, this is a clear variance fromother cutting fluids. The performance of the selected plant cutting fluids in term feed rate on surface roughness are betteroff with very close values, this was similar to what was exhibited with spindle speed on surface roughness.

4.3.5 Morphology of produced chips at specified spindle speed for the selected plant cutting fluids, convectional soluble oil and dry drilling condition.

The various chips obtained during drilling operation of mild steel under specified spindle speed are presented in Plate XV. The chips formed are dependent on varying parameters like feed rate, cutting speed, depth of cut, type of material, tool geometry and type of operation (Jain, 2009).

The chips morphology at varying spindle speeds for the three selected plant cutting fluids, convectional soluble oil and dry drilling condition are obtained as follows: Cutting speed of 80rpm, produces short segmented conical chip for neem seed oil, short segmented curl chip for tiger nut oil, water melon oil and soluble oil butshort segmented burnt chip for dry drilling.Cutting speed of 125rpm produces segmented conical chip for neem seed oil, Short segmented curl chip for tiger nut, water melon seed oil and soluble oil, but long continuous burnt conical chip was produce for dry drilling condition at this spindle speed. Cutting speed of 180 rpm produceslong continuous conical chip for neem seed oil,segmented curl chip for tiger nut oil, and water melon seed oil, Short segmented curl chip for soluble oil, and long continuous burnt spiral chipfor dry drilling. Cutting speed of 280rpm produceslong continuous serrated chip for neem seed oil, long continuous conical chip for tiger nut,Short continuous conical chip for water melon seed oil and soluble oil butlong continuous burnt serrated chip for dry drilling operation.

The variation in chip formation may be due the difference in the percentage of fatty acids present in the oils under investigation (i.e. palmitic, myristic, as well as saponification values). This implies that lubricity of any oil depends on its saponification value which indicates the ease with which the oil forms metallic soap film between the workpiece and the drill tool interface for better lubrication performance(Susan, 2005).It is evident thatat lower spindle speed,chips produced are segmented (discontinuous)for all the drilling environment but dry drilling condition at these speed produce burnt chips despite being segmented. This trend continues for spindle speed of 125rpm, but at 180rpm neem seed oil and dry drilling condition produced continuous chips. Continuous chips wereproduced for all the drilling environment at spindle speed of 280rpm.

4.3.6 Percentage Yield of the vegetable seed under evaluation

Figure 4.5 shows the percentages of oil yield for the three vegetable seeds under evaluation, Neem seed has the highest yield with 57.4% followed by water melon seed with 43.3% and tiger nut with the least yield value of 36.9%. These results are not too deviant from what was obtained with groundnut oil of 50%, cashew nut oil 49.1% (Akiihanmi *et al,* 2008).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The evaluations of these selected plant cutting fluids and dry drilling environment with respect to reduction in temperature generation, characteristic of chips produced and surface roughness measurements were determined and the obtained result were compared with the conventional soluble oil. The following conclusions were drawn from the analysis of the results:

- The least surface roughness of 1.6µm was achieved at spindle speed of 280 rpm using water melon seed oil, followed by 1.7µm for neem seed oil and 1.9µm for tiger nut oil and 2.2μm for conventional soluble oil, it is evident that surface roughness values for plant cutting fluids were very close. Therefore water melon seed oil was the most effective in reducing surface roughness as spindle speed increased. This performance can be attributed to its high viscosity.

- Increase in spindle speed increased the temperature generated irrespective of drilling environment, however water melon seed oil was most efficient in heat reduction with 47ºC at 80rpm and 79ºC at 280rpm, followed by conventional soluble oil having 54ºCat 80rpm and 84ºC at 280rpm, obviously dry drilling condition exhibit the highest temperature generated with 93ºC at 80rpm and 130ºC at 280rpm.The behavior of water melon seed oil and conventional soluble oil could be traced to their closed relative density value.
- The average chipsthickness formed using water melon seed oil as cutting fluid was highest, due to its better lubricating ability. This allows easier and deeper penetration of cutting tool into workpiece and better metal removal rate.
- Increase in feed rate increased the surface roughness value, since increase in feed rate increased material removal rate.
- The percentage yield of the three vegetable oil are moderate in compassion with the likes of groundnut cashew nut. However Neem seed has the highest yield followed by water melon seed and tiger nut has the least yield.
- On the final note it can be established that eco-friendly plant cutting fluids could successfully compete with petroleum-based mineral oils as cutting fluids in metal working operation due to theirgood lubricating propertieswhich can be attributed to the fatty acid composition.

5.2 Recommendation

This research studied the effects of selected plant cutting fluids on temperature, surface finish and chip formation, with specific machining parameters. It is however worthy of note that further research can still be carried out to explore other related areas, therefore the followings are suggested:

- The competitivenessof these selected plant oil will be an anticipated reality if adopted in large scale machining, the blending of these oils with other available cutting fluids would be a well deserve area of research.
- Flooding method was used in the application of these cutting fluids, possibility of other mode of applications such as minimum quantity lubricant (MQL) method should be considered in future research in order to see likely or otherwise the reduction in the quantity of cutting fluid used.
- Proper waste management system that would look into collecting water melon seed and neem seed from any of the followings, consumers, sellers, farmers and fruit juice producers to store the spoilage and post-harvest losses and peelings for cutting fluids and general industrial uses.

5.3 Contribution to Knowledge

Drilling provides a widely used means for machining internally cylindrical, many researches have been carried out on vegetable oils as an alternative means of cutting fluids in metal working processes since they are less toxic and environmentally friendly. As such, this research work indeed established the effectiveness of neem seed oil, tiger nut oil and water melon seed oil as good cutting fluids in drilling operation for the reduction of temperature generation and surface roughness of the workpiece at specific drilling parameters.

REFERENCES

Abdallah, H.S. and Patel, S (2006). "The Performance and Oxidation Stability of Sustainable Metal-working Fluid Derived from Vegetable Extracts". *Proceedings of the Institution of Mechanical Engineers*, Part B: Engineering Manufacturing 220: 2027-2040

Akinhanmi, T.F., Akintokun, P.O., and Atasie, V.N., (2008). Chemical composition and physiochemical properties of cashew nut. J. Agric. Food. Environ. Sci., 2, 4-8.

American Society for Metal (ASM) Hand book (1972). Metal Park, Ohio, Vol III, (8thed). USA.

Anil, J. (2012).Analysis of Tool Wear Rate in Drilling Operation using Scanning Electron Microscope (SEM). Journal of Minerals and Materials Characterization and Engineering, Vol. 11, No.1, pp.43-54.

AOAC (2002). Official methods of analysis of the Association of Official Analytical Chemists (14th ed.), Arlington.

AOCS (1992). Official methods and recommended practices of the American Oil Chemists Society (4th ed.), Champaign, American Oil Chemists' Society, USA.

Aremu, M. O., Ibrahim, H., and Bamidele, T. O. (2015).Physicochemical Characteristics of the Oils Extracted from Some Nigerian Plant Foods – A Review. *Journal of Chemical and Process Engineering Research Vol 32*

Akinoso, R. (2006). Effects of moisture content, roasting duration and temperature on yield and quality of palm kernel (*Elaeisguineensis*) and sesame (*Sesamumindicum)* oils. PhD thesis University of Ibadan, Nigeria.

Avila, R. F.,Abrao, A. M. (2001)."The effect of cutting fluids on the machining of hardened AISI 4340 steel," Journal of Materials Processing Technology; 119:21-26.

Basavarajappa, S., Chandramohan, G., and Davim, J.P. (2008). "Some studies on drilling of hybrid metal matrix composites based on Taguchi techniques," *Journal of Materials Processing Technology*;196:332-338.

Becker, W. (1978). Solvent extraction of soybean. *Journal of American Oil Chemists' Society*, 55(11), 754 – 761.

Bello, M. A. (1994). *Effects of Lubricants on Machined Mild Steel Surfaces*. Unpublished HND Project report, Nigerian Institute of Science and Technology, Federal University of Technology, Department of science Technology, Akure, Nigeria.

Belluco, W., and De Chiffre, L., (2001). "Testing of vegetable-based cutting fluids by hole making operations," Lubrication Engineering; 5 7: 12-16.

Belluco, W., and De Chiffre, L., (2004): "Performance evaluation of vegetable-based oils in drilling austenitic stainless steel,*" Journal of Materials Processing Technology; 148:171-176.*

Boston, O.W. ASME Research Committte, (1952)" Manual on Cutting of Metals with single point tools" Second edition published by ASME,P143-150

Bachmann, J. (2004) Oil seed processing for small scale producers. National sustainable agriculture Information service (2004). Available in: <http://www.attra.ncat.org/attra-pub/PDF/oilseed.pdf>. Retrieved February 2015.

Braga, D.U., Diniz, A.E., Miranda, G.W.A.,Coppini, N.L. (2002): Using a MinimumQuantity of Lubricant (MQL) and a diamond coated tool in the drilling of aluminum-silicon alloys. Journal of Materials Processing Technology 122:127-138

Bralla, G. (1999). *Design for manufacturability handbook.* New York: McGraw-Hill. p. 4-56. ISBN 9780070071391.

Boothroyd, Gand Knight, W.A.(1999). *"Fundamental of Metal Machining and Machine Tools", 3rd* Edition, Washington, D. C.: Script a Book Company.

Byers, J. P. (2006) *Metalworking fluids*, 2nd ed., Boca Raton, Florida: Taylor & Francis

Dane, .F and Liu, J.(2007). Diversity and origin of cultivated and citron type watermelon *(citrilluslanatus*). *Genetic Resources and Crop Evolution*. *Australianjournal of crop science* 5(13), 1832-1836

Davim, J .P. (2008). Machining Fundamental and Recent Advances, XIV, 361 p. 222 illus

DeGarmo, E.P., Black, J.T., Kosher, R.A. (1984)."Materials and Processes inManufacturing Maxwell MacMillan Publication, (7th Edition) New York, USA 578-581.

Diniz, A. E., and Micaroni, R., (2007). "Influence of the direction and flow rate of the cutting fluid on tool life in turning process of AISI 1045 steel," International Journal of

Machine Tools Manufacturing., 47(2), pp. 247–254.

Ekundayo, G. (2004).Determination of Suitable Lubricants from Selected Vegetable Oils for Machining Operation. M.Eng Thesis, University of technology, Department of Mechanical and Production Engineering technology, Akure, Nigeria.

El Baradie, M.A., (1996). "Cutting Fluids, Part I: Characterisation" Journal of Materials Processing Technology 56 (1996) 786-797.

Eyup, B. and Babur, O (2006). Investigation of the effect of drilling conditions on the twist drill temperature during step-by-step and continuous dry drilling. Materials and Design. Vol. 27: 446-454.

Gaminana, J. O., (2011). Evaluation of neem, tiger nut and false walnut oils as metal working lubricants. An unpublished M.Sc. thesis, Ahmadu Bello University, Zaria.

Gawrilow,I (2003). Palm Oil Usage in Lubricants. "Interfacing with the Global Oils and Fats Business" 3rd Global Oils and Fats Business Forum USA.

Galloway, J. P. (1976). Cleaning, cracking, dehulling, decorticating and flaking of oil-bearing materials. *Journal of American Oil Chemists' Society,* 53(6), 271 – 274.

Groover, M.P. (2010). Fundamentals of modern manufacturing: materials, processes and systems, 4th ed. John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030-5774, (201)748-6011.

Gunter, K. and Sutherland, J. (1999)."An experimental investigation into the effect of process conditions on the mass concentration of cutting fluid mist in turning". *Journal of Cleaner Production*, 7, 341-350.

Hassan, A.B., Abolarin, M.S., Nasir, A. and Ratchel, U. (2006), "Investigation on the use of palmolein as lubrication oil". *Leonardo Electronic Journal of Practices and Technologies* 5(8): 1-8, January-June.

Hong, S.Y. and Broomer, M. (2000). "Economical and Ecological cryogenic machining of AISI 304 austenitic stainless steel". *Journals of Cleaner Production* 2: 157-166.

Hydrick, H., (1994). "Coolant Management Concern Invites Change," Lubricants World, 29 and 34.

Internet Link (2015). Properties of 'mobilcut 102'. Retrieved 02 February 2015 from http://www.mobil.com.

Isik.Y, (2010). "An Experimental Investigation on Effect of Cutting Fluids in Turning with Coated Carbides Tool" Strojniškivestnik - Journal of Mechanical Engineering 56(2010)3.

Johnson, L. A. and Lusas, E. W. (1983). Comparison of alternative solvents for oil extraction. *Journal of American oil Chemists' Society*, 60(2), 229 – 241.

Jamiu., K.O and Sharafadeen.K.K, (2013). "Performance Evaluation of Vegetable Oil-Based Cutting Fluids in Mild Steel Machining" *Journal of International Institute for Science, Technology and Education (IISTE) Vol.3 No.9*

Julieb, Z., Andres, F., Kimf, H., and Steven, J. (2003). "Design of hard water stable emulsifier systems for petroleum and bio-based semi-synthetic metalworking fluids, "Environ. Sci. Technol. 37: 5278–5288.

Jain, R.K. (2009). Production technology manufacturing processes, technology and automation, khanna publishers (17th Edition) india.

Jarrard, A. (1993). "Metalworking Fluids Management Programs," Modern Machine Shop, , 81-84.

John, I., (2004): "Emulsions containing vegetable oils for cutting fluid application," Colloids and Surfaces A: Physicochem. Eng. Aspects; 237: 141-150.

Krahenbuhl, U. (2002), "Vegetable Oil-based Coolants Improve Cutting Performance (Cutting Fluids)". Tooling & Production, Nelson Publishing.

Kuram, E. (2009): "Investigation of vegetable-based cutting fluids performance in drilling," M.Sc. Thesis, Gebze Institute of Technology, Gebze-Kocaeli, Turkey.

Kuram, E. Ozcelik, B., Demirbas, E. and Sik E. (2010): "Effects of cutting Parameters on Surface Roughness and Thrust Force" Proceedings of the world Congress on Engineeriong 2010 Vol II, June 30-July2, London, U.K.

Klocke, F and Eisenblatter, Dry cutting, CIRP 46(2) (1997) 519-525

Kalpakjian, S. and Schmid, S.R. (2006.): Manufacturing Engineering and Technology 5th edition, Prentice-Hall Upper Saddle River, NJ - USA, 585-590.

Lopez de Lacalle, L. N., Angulo, C., Lamikiz, A., Sanchez, J. A., (2006). Experimental and numerical investigation of the effect of spray cutting fluids in high speed milling. Journal of Materials Processing Technology, v. 172(1), p. 11-15.

Mattson, M., (2009).*CNC Programming: Principles and Applications* (2nd ed.), Cengage Learning, p. 233, ISBN 9781418060992.

Manikandan,C.andRajeswari, B.(2003), “Study Of Cutting Parameters On Drilling EN24 Using Taguchi Method” International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 7, July – 2013 ISSN: 2278-0181

Naseri, P.M.T. and Tehrani, F. A. (1985): Production of Vegetables Seeds, Dejahad Denshgahi Press of Mashhad (in Persian language), Iran. Pages 50-69.

Narain, M., and Singh, B. P. N. (1988). Characteristics of solvent extraction plants and machinery being made in India. Proceedings of the second National Seminar on soybean processing and utilization, G. B. Pant University of Agriculture and Technology, November 18 – 19, Pantnagar, India.

Nyior, G. B, (1994): Suitability oflocal oils for cold extrusion of aladja ST60-2 structural steels. M.Sc. thesis, AhmaduBelloUniversity, Zaria.

Narinder, G., Naveen, S and Kanwaljeet, S.,(2014) “Analysis of Machining Properties in Dry, Near Dry & Wet Machining on EN9 Steel” *International Journal of Engineering Research and Technology (IJERT) Vol. 3 Issue 8, ISSN: 2278-0181*

Obi, A. I., (2000). Evaluation of the lubricity criteria of vegetable based oils in drilling and some metal forming process, M.Sc thesis, Ahmadu Bello University, zaria.

Obi, A.I. and Oyinlola, A.K. (1996): Frictional Characteristics of Fatty based Oils in Wire Drawing. *Journal of Wear,* 194: 30-37.

Oberg, E., Jones, F.D., Horton, H.L., Ryffel, H.H. (1992) “Machinery’s Handbook,” (New York: Industrial Press Inc., p. 2543.

Osagie, A.U and Eka SA, (1998). Lipid from plant source, structure and distribution. Proc.1st Agricultural Conferenceon Biochemistry of lipids 103:21-26.

Oxford,C.J(1955),"Some experiments in the drilling of metals" Trans American Society of Mechanical Engineers ASME Pt1., p565

Ozcelik, E. Demirbas, E. Kuram, E. Sik, (2009): "Investigation of vegetable oils performance in drilling developed from refined sunflower oil by surface roughness," V. Congress on Machine Design and Production Technologies, Konya, 17-18,39-46.

Prasanna, P.K., Shreelakshmi, .C.T., Shruti.V.H.,andRadha B.N,.(2014). "An Experimental Investigation of Effect of Cutting Fluids on Chip Formation and Cycle Time in Turning of EN-24 and EN-31 Material" *International Journal of Engineering Sciences & Research Technology 3(11)* ISSN: 2277-9655

Randles, S. 1 (1992): Bailey's Industrial Oil and Fat Products, Sixth Edition, Six Volume Set. Edited by FereidoonShahidi. Copyright # 2005 John Wiley &Sons, Inc.

Rassouli, H., (2011), "Conventional Metal Cutting – Understanding the Roles Played by Various Cutting Parameters"-Bright Hub Engineering Inc.

Shaw, M., (1942)TheChemico-Physical Role of the Cutting Fluid. Metal Progress. 85-88.

Salete, M.A. and Joao Fernando Gomes de Oliveira. (2008), "Vegetable based cutting fluid- An environmental alternative to grinding process". *Proceedings at 15th CIRP International Conference on Life Cycle Engineering*, Brazil.

Singh, R., (2006): Introduction to Basic Manufacturing Processes and Workshop Technology, New Age International (P) Limited, Publishers, 4835/24, Ansari Road, Daryaganj, New Delhi – 110002

Silberschmidt V. V., (2009): Measurements of Surface Roughness in Conventional and Ultrasonically Assisted Bone Drilling. Wolfson School of Mechanical and Manufacturing Engineering, Loughborough University, LEI] 3TU, UK

Sokovic, M., and Mijanovic, K., (2001): "Ecological aspects of cutting fluids and itsInfluence on quantifiable parameters of the cutting processes," Journal of Materials Processing Technology; 109:181-189.

Silliman, J.D. and R. Perich.(1992) "Cutting and Grinding Fluids: Selection and Application - Second Edition," (Dearborn, Michigan: Society of Manufacturing Engineers, p.216.

Smith, J. (1987). Production Technology. New Delhi, India

State of Ohio Environmental Protection Agency (SOEPA), (1993) "Extending the Life ofMetal
Working Fluids," (Columbus, Ohio: Pollution Prevention Fact Sheet No.11,p. 4.

Susan, W., (2005): Cutting Tool Engineering Magazine, Volume 57, Number 2.USA www.waterlooscrewmachine.com

Taylor FW (1907) On the art of cutting metals. Trans American Society of Mechanical Engineers ASME 28: 31–58

Tolouei-Rad, M and Shah, A. (2012) "Development of a Methodology for Processing of Drilling Operations" Journal of World Academy of Science, Engineering and Technology vol 72.

Tsao, C. (2007): "An experimental study of hard coating and cutting fluid effect in milling aluminum alloy," International J Advance Manufacturing Technology; 32:885-891

Tuholski, R.J., (1993) "Don't Forget the Cutting Fluid," Journal of Industrial Technology,2-5.

Vaibhav,KA.V., Narendra, S. S and Ramprasad, C (2012) "Vegetable Oil-Based Metal Working Fluids-A Review"*International Journal on Theoretical and Applied Research in Mechanical Engineering (IJTARME)Volume-1, Issue-1,*

Willing, A., (2001), Lubricants based on renewable resources – an environmentally compatiblealternative to mineral oil products, Chemosphere, 43, pp. 89-98.

Xavior, M. A., (2009): "Determining the influence of cutting fluids on tool wear and surface roughness during turning of AISI 304 austenitic stainless steel," Journal of Materials Processing Technology; 209:900-909.

Zajac, J. (2007).Developed Trends in a Research of Processing Fluids. In Manufacturing Engineering, Faculty of manufacturing technologies TU of Košice with the seat in Prešov,2007, n.2, p. 36-38, [online]. [cit.2008-01-08]. Available on the Internet:http://web.tuke.sk/fvtpo/casopis/skindex.htm

APPENDICES

Table 1: Variation of spindle speed and constants depth of cut (40mm) on temperature (ºC) and drilling time (sec) for various cutting fluids, and dry drilling environment.

S/N	**Cutting Fluids**	**Spindle Speed (rpm)**	80	125	180	280
1	Neem Seed oil	Temperature (ºC)	63	72	85	101
		Drilling Time (sec)	205	229	247	249
2	Tiger Nut oil	Temperature (ºC)	58	65	79	95
		Drilling Time (sec)	208	224	237	242
3	Water Melon Seed oil	Temperature (ºC)	47	58	65	79
		Drilling Time (sec)	200	211	225	236
4	Soluble oil	Temperature (ºC)	54	68	74	84
		Drilling Time (sec)	203	217	228	237
5	Dry drilling	Temperature (ºC)	93	105	109	130
		Drilling Time (sec)	260	317	396	332

Table 2: Variation of spindle speed, feed rates and constants depth of cut (40mm) on chip thickness (mm) for various cutting fluids and dry drilling environment.

S/N	**Cutting Fluids**	**Spindle Speed (rpm)**	80	125	180	280
		Feed rate (mm/rev)	0.25	0.17	0.10	0.05
1	Neem Seed oil	Chip Thickness (mm)	0.62	0.53	0.43	0.38
2	Tiger Nut oil	Chip Thickness (mm)	0.58	0.48	0.41	0.35

3	Water Melon Seed oil	Chip Thickness (mm)	0.67	0.58	0.49	0.45
4	Soluble oil	Chip Thickness (mm)	0.64	0.56	0.45	0.42
5	Dry drilling	Chip Thickness (mm)	0.45	0.35	0.31	0.20

Table 3: Variation of spindle speed, feed rates and constants depth of cut (40mm) on surface roughness (μm) for various cutting fluid and drilling environment.

S/N	Cutting Fluids	Spindle Speed (rpm)	80	125	180	280
		Feed rate (mm/rev)	0.25	0.17	0.10	0.05
1	Neem Seed oil	Surface roughness (μm)	4.2	3.5	2.8	1.7
2	Tiger Nut oil	Surface roughness (μm)	4.8	3.7	2.3	1.9
3	Water Melon Seed oil	Surface roughness (μm)	3.9	2.8	2.5	1.6
4	Soluble oil	Surface roughness (μm)	6.0	4.7	3.8	2.2
5	Dry drilling	Surface roughness (μm)	9.7	7.5	6.8	4.2

Analysis 01
Cont
Group
Sample No: [Engr. Ibrahim]

AN=1211 TAN=1222
GLOBAL Common Group

Friday, June 05 2015 13:49

C = 0.2421	P = 0.0049	Cr = 0.0105	Si = 0.2020	Mn = 0.7374	Mo = 0.0011
S = 0.0107	Ni = 0.1067	V = 0.0005	W = 0.0065	Co = 0.0004	Zn = 0.0017
As = 0.0006	Al = 0.0013	Cu = 0.0036	Sn = 0.0022	Pb = 0.0005	Fe = 97.6822

DICON

DEFENCE INDUSTRIES CORPORATION OF NIGERIA
Towards National Defence and Enterprise (RESEARCH AND DEVELOPMENT CENTRE)

NATIONAL RESEARCH INSTITUTE FOR CHEMICAL TECHNOLOGY P.M.B 1052, ZARIA.

VISCOSITY TEST RESULT

NDJ-S 8S VISCOMETER

NAME AMASA IBRAHIM A. ORGANISATION

Label	Viscosity mpa.s	Percent%	Speed rpm	Temperature °C
Neem	499.0	24.9	60	27.5
W. Melon	504.3	25.2	60	27.5
T. Nut	499.3	24.9	60	27.6

Analyst Name/Sign Abubakar Abdullahi Date 28/07/2015

28 JUL 2015 DIRECTOR GENERAL

NATIONAL RESEARCH INSTITUTE FOR CHEMICAL TECHNOLOGY

P.M.B 1052 ZARIA

PHYSICOCHEMICAL ANALYSIS AND RESULT SHEET

Name of Students/ Organization: AMASA I. Abubakar

SAMPLES	RELATIVE DENSITY	REFRACTIVE INDEX	SAPONIFICATION VALUE	PEROXIDE VALUE	ACID VALUE	LODIN VALUE	% FREE FATY ACID	Viscosity
T. Nut	0.9015	1.4644	186.5	1.29	3.478	111.04		
Neem Seed	0.9447	1.4738	217.4	1.46	7.433	107.86		
W. Melon	0.9181	1.4706	200.5	0.42	3.254	142.13		

Name of Analysis: Abubakar Abdullahi Sign / Date: 23/07/2015

P.M.B 1052 ZARIA

PHYSICOCHEMICAL ANALYSIS AND RESULT SHEET

e of Students/ Organization .... Amasa I. Abubakar ....

AMPLES	RELATIVE DENSITY	REFRACTIVE INDEX	SAPONIFICATION VALUE	PEROXIDE VALUE	ACID VALUE	LODIN VALUE	% FREE FATY ACID	
entional oil	0.9210	1.2523	190.5	0.33	5.642	132.24		5(

me of Analysis ... Abubakar Abdullahi .... Sign / Date ... AAB 25/07/[illegible]